The Pricing of Bank Bonds, Sovereign Credit Risk and ECB's Asset Purchase Programmes*,†,‡

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Abstract

The 2008 Global financial crisis and the subsequent European sovereign debt crisis deteriorated banks funding conditions and lead to a substitution effect among bond instruments. We examine the pricing of straight, covered and securitization bonds issued by European banks in the 2000-2016 period, with a particular focus on the effect of sovereign credit risk and ECB's asset purchase programmes on spreads. We find that (i) straight, covered and securitization bonds are priced in segmented markets, (ii) the impact of common pricing determinants on spreads differ significantly between non-crisis and crisis periods, (iii) sovereign credit risk is an important determinant of banks' cost of funding, especially in crisis periods, (iv) ECB's asset purchase programmes exhibited mixed effectiveness in improving banks funding conditions, (v) contractual bond characteristics other than credit ratings, macroeconomic factors and bank characteristics are important determinants of spreads, and (vi) there is evidence of heterogeneity across countries.

JEL Classification: E52; G01; G12; G21; G32

Keywords: Straight Bonds; Covered Bonds; Securitization Bonds; Bond Pricing; Sovereign Risk; Asset Purchase Programmes

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1. Introduction

Straight bonds, covered bonds and securitization bonds are among the most significant sources of bank debt financing, in both Europe and the U.S. (Loutskina, 2011; Marques and Pinto, 2020). However, they differ in the level of protection provided to investors in the event of bankruptcy. While the credit risk of straight bonds depends essentially on the issuing bank's creditworthiness, covered and securitization bonds provide investors, in the case of the bank's default, with a first claim on a ring-fenced pool of assets and all proceeds from their servicing.[1] As such, covered and securitization bonds are, from the perspective of banks, regarded as closer substitute instruments (Markmann, 2018). It is not, thereby, surprising that the 2008 financial crisis induced a substitution effect: the demand for securitization bonds reduced, due to the important role played by securitization in the development and propagation of the crisis, while the demand for covered bonds increased, making it an important source of financing (or refinancing) for the European banking system.[2][3]

Covered and securitization bonds are, from the perspective of central banks, also regarded as complementary instruments. In particular, Carbó-Valverde *et al.* (2017) and Boesel *et al.* (2018) point out that covered bonds and securitization bonds are complementary instruments in enhancing the effectiveness of monetary policy and the integration of capital markets. Given that the 2008 financial crisis paved the way to an European sovereign debt crisis that impacted the credit risk of banks and put the integration of capital markets under risk,[4] it is

[1] In particular, covered bonds are dual-recourse bonds, with a claim on both the bank issuer and a cover-pool of assets that serves as collateral, which usually remain on the issuer's balance sheet and are 'ring-fenced' to give investors greater protection in the event of bankruptcy (Packer *et al.*, 2007; Schwarcz, 2011; Prokopczuk *et al.*, 2013). Securitization bonds, on the other hand, are issued as subordinated, negotiable contingent claims (tranches) with varying seniority and maturity, backed by the credit payment performance of the securitized assets, transferred to another entity created for the sole purpose of holding those financial claims (Roever and Fabozzi, 2003; Gorton and Metrick, 2013; Alves and Pinto, 2016).

[2] Source: European Central Bank, 2012, "Changes in Bank Financing Patterns".

[3] According to the European Covered Bond Council, covered bond issuance in Europe increased significantly from less than €100 billion in the mid-1990s to €350 billion in 2006. In 2010, for the first time ever covered bond issuance exceeded the issuance of senior unsecured bonds, with a total issuance of €599.2 billion. Source: European Covered Bond Council, 2019, "European Covered Bond Fact Book 2019", available at http://www.ecbc.eu/.

[4] The impact of the European sovereign debt crisis on bank risk is consistent with the theoretical literature on

not surprising that, in order to address these issues, the ECB implemented three covered bond purchase programmes, in 2009 (CBPP1), 2011 (CBPP2) and 2014 (CBPP3), along with the first asset-backed securities purchase programme in 2014 (ABSPP) and the corporate sector purchase programme in 2016 (CSPP). This fostered (even further) the European market for covered bonds and the revival of the securitization market (between 2009 and 2016, a total of €2,290.6 billion of securitized instruments were issued in Europe).[5]

In this article, we examine how sovereign credit risk and ECB's asset purchase programmes affect the pricing of straight (9,783 bonds, worth €3,934.2 billion), covered (15,197 bonds, worth €3,465.2 billion), and securitization bonds (10,771 bonds, worth €2,674.8 billion), issued by European banks between January 1, 2000 and December 31, 2016, while controlling for (i) contractual characteristics, (ii) other macroeconomic factors, and (iii) originating/issuing bank characteristics. This time frame is selected to provide a full analysis of the pre-crisis period as well as the 2008 financial crisis and the subsequent European sovereign debt crisis.

We contribute to three strands of the literature. The first strand relates to the literature that examines the determinants of bond spreads. Even though this literature has significantly studied the determinants of the spreads of straight bonds,[6] research on the determinants of the spreads of covered bonds and securitization bonds is relatively scant. Regarding covered bonds, the literature has focused mainly on the German market (Breger and Stovel, 2004; Koziol and Sauerbier, 2007; Kempf *et al.*, 2012; Prokopczuk *et al.*, 2013), with limited research being carried out on international markets. A few exceptions are Beirne *et al.* (2011),

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the relation between sovereign and bank credit risk. Bolton and Jeanne (2011), Acharya and Rajan (2013), and Gennaioli *et al.* (2014) consider that the default of a sovereign induces collateral damage to banks. Acharya *et al.* (2014) extends this literature by presenting a model which also includes the transmission of risk from the financial sector to the sovereign. Farhi and Tirole (2018) point out that feedbacks between bank and sovereign risks can lead to a 'doom loop', as a result of which both banks and their sovereigns can end up in a crisis simultaneously.

[5] Source: Securities Industry and Financial Markets Association, 2018, "Securitisation Data Report, European Structured Finance, Q4: 2018", available at https://www.sifma.org/. In this academic study, we define Europe to include countries belonging to the European Economic Area plus Switzerland.

[6] See, among others, Collin-Dufresne *et al.* (2001), Elton *et al.* (2001), Campbell and Taksler (2003), Hull *et al.* (2004), Gabi and Sironi (2005), Longstaff *et al.* (2005), Chen *et al.* (2007), and Flannery *et al.* (2012).

Prokopczuk and Vonhoff (2012), and Gürtler and Neelmeier (2018). Regarding securitization bonds, extant empirical literature focuses on the U.S. market, despite the relevance and size of the European market. A few exceptions are Vink and Thibeault (2008), An *et al.* (2011), Fabozzi and Vink (2012), and Marques and Pinto (2020). We contribute to this literature by examining (and comparing) the determinants of the spreads of straight, covered and securitization bonds on the European market, in non-crisis versus crisis times. To the best of our knowledge this has not been examined in any other academic study.[7] This issue is particularly important due to (i) the significant growth of the European covered bond market, which contrasts with the negligible issuance of covered bonds in the U.S. (€12.9 billion, concentrated in 2006, €4.0 billion, and 2007, €8.9 billion), and (ii) the key role of the securitization market as a funding and risk transfer instrument.[8]

The second strand relates to a recent and growing literature that examines the relationship between sovereign credit risk and bank credit risk. Alter and Schüler (2012), Dieckmann and Plank (2012), De Bruyckere *et al.* (2013), Acharya *et al.* (2014), Yu (2017), and Li and Zinna (2018) examine this relationship during the 2008 financial crisis and the European sovereign crisis. We contribute to this literature by examining the impact of the sovereign credit risk on bond spreads (in the lines of Acharya *et al.*, 2014; and Li and Zinna, 2018) for straight, covered and securitization bonds on the European market, controlling for other macroeconomic factors, as well as contractual and originating/issuing bank characteristics that arguably affect pricing. To the best of our knowledge this has not been examined in any other academic study.

The third strand relates to the literature that investigates the impact of ECB's asset purchase programmes on the bank funding conditions of the Euro area. This literature has focused mainly on covered bonds and on the CBPP1, CBPP2 and CBPP3 (Beirne *et al.*, 2011;

[7] Our analysis uses a dataset of European straight, cover and securitization bonds, constructed using a hand-matching procedure to merge bond information extracted from DCM Analytics and banks' characteristics drawn from Bankscope.

[8] Source: Bank of England and European Central Bank, 2014, "The Case for a Better Functioning Securitisation Market in the European Union".

Schuller, 2013; Szczerbowicz, 2015; Gibson *et al.,* 2016; Markmann and Zietz, 2017; Gürtler and Neelmeier, 2018), with mixed results. Beirne *et al.* (2011) find that the CBPP1 led to a narrowing of covered bond spreads, which is consistent with the ECB objective of promoting the ongoing decline in money market term rates. Szczerbowicz (2015) and Gibson *et al.* (2016) present similar results for both CBPP1 and CBPP2. However, the results in Schuller (2013) and Gürtler and Neelmeier (2018) seem to suggest that the CBPP2 was not an effective mechanism for lowering spreads. Markmann and Zietz (2017) find that for CBPP2 and CBPP3, the results are mixed, with a tendency for a lower impact. We contribute to this literature by analyzing the effectiveness (i) of all three CBPPs on European covered bond primary market spreads,[9] and (ii) of all three CBPPs, the ABSPP and the CSPP on European straight and securitization bond primary market spreads. To the best of our knowledge this has not been examined in any other academic study.

In order to examine how sovereign credit risk and ECB's asset purchase programmes affect the pricing of European bank bonds, while controlling for contractual characteristics, other macroeconomic factors and originating/issuing bank characteristics, we make use of a reduced-form pricing model, in the lines of existing pricing models for corporate bonds and securitization securities (e.g., Campbell and Taksler, 2003; Gabbi and Sironi, 2005; Chen *et al.*, 2007; Marques and Pinto, 2020). The results suggest that straight, covered and securitization bonds issued by banks are priced in segmented markets and that the impact of common pricing determinants on spreads differ significantly between pre-crisis and crisis periods.

Further, the results also suggest that while sovereign credit risk is not an important variable in determining banks cost of funding in the period prior to the 2008 Global financial crisis, it is so during this financial crisis and the subsequent European sovereign debt crisis, for which we find a positive relationship between sovereign credit risk (proxied by the 10-year's sovereign

[9]So far, the literature has focused on the CBPPs' effects on the secondary market (Beirne *et al.*, 2011; Szczerbowicz, 2015; Gibson *et al.*, 2016; Markmann and Zietz, 2017; Gürtler and Neelmeier, 2018). We extend this literature by focusing on ex ante or primary market spreads.

bond yields) and the spreads of straight, covered and securitization bonds.

Furthermore, the results also suggest that the five asset purchase programmes exhibited mixed effectiveness in reaching their target of improving funding conditions for banks (by lowering yields and, thereby, fostering a larger credit supply). While the results obtained for the CBPP1 show strong signs of reaching its goals, results obtained for CBPP2 are not consistent with the ECB's objectives. This can be potentially explained by the fact that the CBPP2 was announced simultaneously with other monetary policy measures that reduced interest and/or investors already knew the effects of outright covered bond purchases. As pointed out by Bernanke (2020), initial rounds of asset purchase programmes were particularly effective because they were introduced in a period of exceptional dysfunction in financial markets. If later programs were anticipated, their effects would have been incorporated into asset prices after ECB formal announcements. The results also show a significant negative impact of the CBPP3/ABSPP on covered bond spreads, while suggesting that the CSPP did not reach the ECB goal of reducing securitization bond spreads. Moreover, we find some spillover effects of asset purchase programmes on different bond markets.

Finally, the results also suggest that contractual bond characteristics other than credit ratings (e.g., time to maturity, transaction size, number of banks involved), macroeconomic factors and bank characteristics are also important determinants of bond spreads. Moreover, they also suggest that (i) the pricing of bonds, (ii) the relationship between sovereign credit risk and bank credit risk, and (iii) the impact of the ECB's asset purchase programmes, can be heterogeneous across countries.

This article is organized as follows: Section 2 characterizes (and distinguishes) straight, covered and securitization bonds, Section 3 reviews the relevant literature, Section 4 presents the research hypotheses and the econometric method, Section 5 describes the empirical application, Section 6 outlines extensions and section 7 concludes.

2. Straight, Covered and Securitization Bonds

Straight, covered and securitization bonds differ in their recourse structure. Covered bonds are a category of straight bonds collateralized by high quality loans (typically composed of mortgages and public sector loans), ring-fenced to provide investors a preferential claim in case of an issuer default, independently of the lender institution's going concern (Packer *et al.*, 2007; Schwarcz, 2011). Securitization bonds are the result of a process by which a bank pools its interest in identifiable future cash flows, transfers the claims on those future cash flows to another entity created for the sole purpose of holding those financial claims, and then issues negotiable securities. Securitization bonds are, therefore, also collateralized by a pool of assets, prioritizing the cash flows of the underlying collateral in a way that each senior tranche has absolute priority over the junior ones (Leland, 2007; Gorton and Metrick, 2013).[10] This implies that while in straight bonds the credit risk depends essentially on the issuing bank's creditworthiness, covered and securitization bonds provide investors, in the case of the bank's default, with a first claim on a ring-fenced pool of assets and all proceeds from their servicing, which may not be utilized to settle any general claims before all claims from those investors are satisfied and, thus, provides a first recourse (Larsson, 2013; Markmann, 2018).

However, there are important distinctions between covered and securitization bonds. First, in covered bonds, banks are required to maintain the quality of the cover pool and the level of 'overcollateralization', which reduces default and liquidity risk for bondholders (Larsson, 2013; Carbó-Valverde *et al.*, 2017; Boesel *et al.*, 2018), while in securitization bonds there is a fixed asset pool and a true sale, leading to banks' capital relief. Second, in covered bonds, if the cover pool is not sufficient, investors may claim a second, *pari passu* recourse from

[10] The markets for the securities issued through securitization are composed of three main classes: (i) asset-backed securities (ABS), backed by consumer-backed products, (ii) mortgage-backed securities (MBS), backed by mortgages, and (iii) collateralized debt obligations (CDOs), backed by debt obligations such as investment grade and high-yield corporate bonds, emerging market bonds, MBS, ABS, bank loans, and other instruments (Alves and Pinto, 2016).

the bank's assets. Third, the 'bankruptcy remoteness' feature provided by the instrumental special purpose vehicle (SPV) in securitization, isolating cash flow generating assets from the originator, is not available in on-balance-sheet funding such as straight or covered bonds (Ayotte and Gaon, 2011).[11,12]

3. Literature Review

The relevant literature can be divided into three strands.

3.1. Determinants of Bond Spreads

The first strand of the literature examines the determinants of bond spreads and is very much focused on straight bonds. Compared with the large amount of empirical studies on corporate bond spreads, research on covered and securitization bond spreads has been scant. Regarding straight bonds, virtually all empirical studies on spreads find credit ratings to be one of its most important determinants (Elton *et al.*, 2001; Hull *et al.*, 2004; Gabbi and Sironi, 2005; Longstaff *et al.*, 2005). Nevertheless, other factors are also found to be important: maturity (Fons, 1987; Sarig and Warga, 1989; Helwege and Turner, 1999), liquidity (Longstaff *et al.*, 2005; Chen *et al.*, 2007), systematic risk (Elton *et al.*, 2001), incomplete accounting information (Flannery *et al.*, 2012), leverage (Flannery *et al.*, 2012), and taxes (Elton *et al.*, 2001). Market variables, like the level of interest rates, the slope of the yield curve and market volatility, are also found to have a significant impact on the spreads of straight bonds (Campbell and Taksler, 2003; Krishnan *et al.*, 2005). For the particular case of bank bonds, Zaghini (2014) shows that credit rating, government guarantees, sovereign credit risk, and the systemic relevance of issuing institutions also affect significantly their spreads.

[11] In securitization, additional credit enhancement mechanisms like excess spread, overcollateralization, cash reserve accounts, or a monoline guarantee, are typically assigned to the SPV to improve the credit rating of the issued bonds (Roever and Fabozzi, 2003).

[12] An additional important difference between securitization and straight bonds is that the latter are rated ex-post while securitized bonds are rated ex-ante. See Marques and Pinto (2020) and references therein.

Regarding covered bonds, the literature has focused mainly on the German market, with limited research being carried out on international markets. Breger and Stovel (2004), Koziol and Sauerbier (2007), and Kempf *et al.* (2012) find that while liquidity affects spreads significantly, individual bond ratings do not have a significant impact on German covered bond pricing, as the probability of default is marginal. Prokopczuk *et al.* (2013) show that the credit quality of the cover-pool assets and whether they are covered by public sector or mortgage loans also impact bond spreads. Considering international markets, Prokopczuk and Vonhoff (2012) show that developments in the real estate sector, legislative frameworks, country-specific differences and liquidity explain the pricing of mortgage covered bonds. In line with Beirne *et al.* (2011) and Prokopczuk and Vonhoff (2012), Gürtler and Neelmeier (2018) find that macroeconomic variables, like interest rate level and market volatility, and exogenous events, like the financial crisis and the sovereign debt crisis, impact significantly risk premiums of public covered bonds.

Regarding securitization bonds, the literature has focused mainly on the U.S. market. Vink and Thibeault (2008) show that ABS, MBS and CDO are influenced differently, but by common pricing characteristics. Ammer and Clinton (2004), Fabozzi and Vink (2012), and Marques and Pinto (2020) show that credit rating is the most important pricing factor for securitization bonds. However, extant empirical studies show that investors also rely on factors other than credit ratings when pricing asset-backed claims (An *et al.*, 2011; Fabozzi and Vink, 2012; Marques and Pinto, 2020). These include: (i) contractual characteristics, like maturity, transaction size, number of banks involved and their reputation, and the type and level of credit enhancement mechanisms used; (ii) the underlying asset pool's performance; and (iii) macroeconomic factors, like market volatility, yield curve slope, level of creditor legal protection, country risk, and legal enforcement.

3.2. Relationship between Sovereign Credit Risk and Bank Credit Risk

The second strand of the literature examines the relationship between sovereign credit risk and bank credit risk - both theoretical and empirically. This strand of literature has flourished

with the unwind of the 2008 financial crisis and the massive bank bailouts applied to the financial sector worldwide (e.g., Bolton and Jeanne, 2011; Dieckmann and Plank, 2012; Acharya and Rajan, 2013; De Bruyckere *et al.*, 2013; Demirgüç-Kunt and Huizinga, 2013; Gennaioli *et al.*, 2014; Kallestrup *et al.*, 2016). This literature provides evidence that there is a linkage between bank and sovereign credit risk and that it increases significantly in times of financial crisis.[13] Alter and Schüler (2012), using daily CDS between June 2007 and May 2010, find that before bank bailouts, the increase in countries' default risk has its origin in the financial sector, while afterwards government CDS spreads become an important determinant of banks' CDS, mainly in the short run.[14] Similarly, Dieckmann and Plank (2012) and Yu (2017) document a significant rise in bank and sovereign CDS comovement following the collapse of Lehman Brothers. Demirgüç-Kunt and Huizinga (2013) and De Bruyckere *et al.* (2013) use international samples of banks to show that bank size and public finance conditions, namely the country's debt ratio, are important drivers of contagion between bank and sovereign risks. Acharya *et al.* (2014) also study this 'loop' and find that, after the bank bailouts during the 2008 financial crisis, a 10% increase in the level of sovereign CDS leads to 0.9% increase in bank CDS. Using CDS spreads data for 10 eurozone countries, Erce (2015) shows that the impact of sovereign risk on bank risk is higher for countries with larger stock of public debt.[15] More recently, Gennaioli *et al.* (2018) show that banks on average hold a significant share of their assets in government bonds and that this 'dangerous embrace' between banks and their government plays a key role during sovereign defaults, while Li and Zinna (2018) show that about one third of banks' credit risk is sovereign.

[13] Until the collapse of Lehman Brothers, contagion episodes where primarily from sovereign to banks. However, since the dawn of the financial crisis that several studies point to a bidirectional linkage between bank and sovereign risk (Alter and Schüler, 2012; Acharya *et al.*, 2014; Erce, 2015; Yu, 2017). The 2008 financial crisis and the subsequent European sovereign crisis showed that the link between the state and the banking system is umbilical. At first, sovereign took in the credit risk of the banks by introducing rescue packages. Then, the deterioration of fiscal conditions had an adverse impact on banking system's stability (Li and Zinna, 2018).

[14] For further details on bank bailouts see Bhattacharya and Nyborg (2013), Drechsler *et al.* (2016) and references therein.

[15] Erce (2015) also shows that sovereign risk feeds into bank risk more strongly than vice-versa.

Finally, the literature also provides evidence that governments of higher creditworthiness provide an implicit guarantee to the (domestic) banking system. Levy and Zaghini (2011) find that bond spreads paid by banks at issuance reflect mainly the creditworthiness of the guarantor and not contractual or banks characteristics. Zaghini (2014) shows that countries with a AAA sovereign credit rating provide a safety net to (domestic) banks, while banks located in countries with worse credit ratings face higher spreads, namely in crisis periods. Similarly, Acharya *et al.* (2014) show that the feedback loop between the credit risk of sovereigns and banks is due to not only to bank's holdings of sovereign, but also to the implicit and explicit guarantees provided by governments. Correa *et al.* (2014) find that sovereigns and domestic banks to be markedly interconnected, partly through government guarantees and that this effect is stronger for banks in countries with better creditworthiness. More recently, Kallestrup *et al.* (2016) show that government guarantees initially mitigated the spread increase of distressed banks but, in turn, became a significant source of European sovereign risk after 2008. This literature implies that the relation between banking and sovereign credit risk must be separated from the implicit guarantee that governments of higher creditworthiness provide to the (domestic) banking system.

3.3. ECB Asset Purchase Programmes

The third strand relates to the literature that investigates the impact of ECB's asset purchase programmes on the bank funding conditions of the Euro area. These asset purchase programmes have been instrumental in the development of the European market for covered bonds as well as in the revival of the securitization market after the 2008 financial crisis. They consist of three CBPP in 2009, 2011 and 2014 (CBPP1, CBPP2 and CBPP3, respectively) and the ABSPP, also in 2014. Between 2014 and 2016, the CBPP3 and ABSPP were embedded in a broader asset purchase programme, including public sector bonds, in 2015, and the CSPP, in 2016. After several extensions, in November 1st, 2019 the Eurosystem restarted net purchases under the asset purchase programmes. Through direct purchases in primary and secondary markets, the ECB aimed to foster a decline in money market term

rates, easing funding conditions for banks, and to improve debt market liquidity.[16]

The literature on the impact of ECB's asset purchase programmes on both credit markets and pricing of bank debt instruments is relatively scant (Markmann, 2018) and has focused mainly on covered bonds and on the CBPP1, CBPP2 and CBPP3.[17] Beirne *et al.* (2011) find that the CBPP1 has fulfilled its primary objectives, by stimulating considerably the issuance of covered bonds in the primary market and improving funding conditions for the Eurozone banks. Szczerbowicz (2015) and Gibson *et al.* (2016) find the CBPP1 and CBPP2 to be have been effective mechanisms for lowering covered bond spreads. Schuller (2013) points out that the overall effect of CBPP2 on the spreads was different between core Europe and distressed European countries, where the primary market virtually ran dry. Similarly, Gürtler and Neelmeier (2018) find that while there is evidence that the CBPP1 lowered the risk premiums of public covered bonds, the same is not true for the CBPP2. Markmann and Zietz (2017) find a 10 to 11 bps tightening of covered bond spreads upon the announcement of the CBPP1, while for CBPP2 and CBPP3, the results are mixed. Further, while the results suggest an insignificant or a significant positive impact of the CBPP2 on credit spreads, they suggest the impact of the CBPP3 to be country driven. Szczerbowicz (2015) and Markmann (2018) explain the failure of the CBPP2 in reducing covered bond spreads based on two major aspects: (i) to mitigate the continued difficulty of banks attaining sufficient funding, the ECB announced two twelve-month LTRO operations in October 2011 and expanded the December LTRO facility to 36 months for December and February 2012, which provided banks with

[16]The ECB responded to the global financial crisis by conducting a number of unconventional monetary policy measures in addition to lowering the policy rate and the asset purchase programmes. In particular, the ECB switched to regular open market operations with fixed rates and full allotment that were provided with longer maturities, relaxed collateral requirements, changed the modalities of its long-term refinancing operations and imposed a negative interest rate on its deposit facility. See, among others, Bluwstein and Canova (2016) and Markmann and Zietz (2017).

[17]There is also some literature on the impact of asset purchase programmes on securitization bonds, but it is focused exclusively on the U.S. market (Hamilton and Wu, 2012). Krishnamurthy and Vissing-Jorgensen (2011) find that the Federal Reserve's Large-Scale Asset Purchases 1 (LSAP1) has led to lower MBS and corporate yields. Hancock and Passmore (2011) find that MBS and sovereign bond purchases lead to a tightening of MBS yields, while Bernanke (2020) shows that the LSAP1 announcement reduced significantly bond yield spreads: -100 bps for 10-year Treasuries, -129 bps for MBS, and -89 bps of AAA corporate bonds.

a total liquidity of €842.5 billion; and (ii) between September 2011 and January 2012, the ECB had increased the monetary base by 50%.[18] Concerning the CBPP3, Markmann (2018) points out that at the time of its announcement, market participants recognized that there was no need for a CBPP from a bank funding perspective, as spreads were mostly trading as tightly as in pre-crisis levels.

4. Hypothesis Development and Econometric Method

4.1. Hypothesis Development

Contrary to straight bonds, where the spread depends essentially on the issuing bank's characteristics, the spread of securitization bonds depends, instead, on the assets pledged as collateral and on the credit enhancement mechanisms used (Liu *et al.*, 2018; Marques and Pinto, 2020). Due to the dual-recourse feature of covered bonds, their spread depend on banks' accounting and financial characteristics as well as on the cover-pool of cash flow generating assets (Larsson, 2013). This leads us to hypothesize:

Hypothesis 1. *Straight, securitization, and covered bonds are differently priced.*

As pointed out by Kara *et al.* (2019), during good states of a credit cycle it might be more difficult for investors to assess the true value of information-intensive securities. Additionally, securitization market regulations changed significantly during the crisis period.[19] Gürtler and Neelmeier (2018) show a significant impact of sovereign credit risk and macoreconomic variables, namely financial crisis and the sovereign debt crisis, on spreads. As there could be a structural break in pricing bond securities in pre- versus crisis period, we raise the following hypothesis:

Hypothesis 2. *The impact of pricing factors on bond spreads differ significantly between pre-crisis and crisis periods.*

[18] Consequently, under CBPP2 the Eurosystem acquired only €16 billion of covered bonds (37% in the primary and 63% in the secondary market), despite the targeted purchase volume of €40 billion.

[19] Source: Basel Committee on Banking Supervision, 2014, "Basel III Document: Revisions to the Securitisation Framework".

The literature that examines the relationship between sovereign credit risk and bank credit risk, both theoretical (Bolton and Jeanne, 2011; Acharya and Rajan, 2013; Gennaioli *et al.,* 2014; Acharya *et al.*, 2014; Farhi and Tirole, 2018) and empirical (Alter and Schüler, 2012; Dieckmann and Plank, 2012; Demirgüç-Kunt and Huizinga, 2013; De Bruyckere *et al.*, 2013; Acharya *et al.,* 2014; Erce, 2015; Yu, 2017; Gennaioli *et al.*, 2018; Li and Zinna, 2018) suggest a positive linkage between the two credit risks. Further, the literature that examines the impact on bank credit risk of the implicit guarantee that governments of higher creditworthiness provide to the (domestic) banking system (Levy and Zaghini, 2011; Acharya *et al.,* 2014; Correa *et al.*, 2014; Zaghini, 2014; Kallestrup *et al.,* 2016) implies that the relation between banking and sovereign credit risk must be separated from this implicit guarantee and suggest a negative linkage between the implicit guarantee and banks credit risk. As such, we raise the following hypotheses:

Hypothesis 3. *The sovereign credit risk has a positive impact on bond spreads.*

Hypothesis 4. *Governments with AAA credit rating provide implicit guarantee to domestic banking system, leading to a reduction in bond spreads.*

Bluwstein and Canova (2016) show that unconventional monetary policy announcements lead to financial market responses, which are similar to conventional monetary shocks. This combined with the results of the literature that examines the impact of ECB's asset purchase programmes on both credit markets and pricing of bank debt instruments (Beirne *et al.*, 2011; Szczerbowicz, 2015; Gibson *et al.,* 2016; Markmann and Zietz, 2017; Gürtler and Neelmeier, 2018) leads to the following hypothesis:

Hypothesis 5. *ECB's asset purchase programmes had a negative impact on bond spreads.*

4.2. Econometric Method

In order to examine empirically the above hypotheses, we propose a reduced-form pricing model along the lines of existing bond pricing models (Campbell and Taksler, 2003;

Gabbi and Sironi, 2005; Chen *et al.*, 2007; Marques and Pinto, 2020). Suppose we observe information on a collection of I_s bonds (or bond tranches) of each category $s = \{\text{straight}, \text{covered}, \text{securitization}\}$, indexed by $i = 1, \ldots, I_s$, issued by B banks, indexed by $b = 1, \ldots, B$, operating in M countries, indexed by $m = 1, \ldots, M$, and referent to T days, indexed by $t = 1, \ldots, T$, which cover the pre-crisis period as well as the 2008 financial crisis and the subsequent European sovereign debt crisis. Let $c = \{\text{pre-crisis}, \text{crisis}\}$ denote the period to which each day t refers. The estimation equation is given by:

$$\begin{aligned} spread_{isbmt} \;=\; & \beta_{1sc} SR_{mt} + \beta_{2sc} AAA_{mt} + \beta_{3sc} CBPP1_t + \beta_{4sc} CBPP2_t \\ & + \beta_{5sc} CBPP3/ABSPP_t + \beta_{6sc} CSPP_t + \boldsymbol{\gamma}_{sc} \mathbf{x}_{isbmt} + \boldsymbol{\varphi}_{sc} \mathbf{w}_{mt} \\ & + \boldsymbol{\delta}_{sc} \mathbf{v}_{bmt} + u_{smc} + \varepsilon_{isbmt}, \end{aligned} \tag{1}$$

where $spread_{ismt}$ denotes the spread of bond (or bond tranche) i of category s issued by bank b in country m and day t, SR_{mt} denotes the sovereign risk of country m in day t, and AAA_{mt} denotes an indicator variable that takes the value one if country m in day t has AAA credit rating (and takes the value zero otherwise). $CBPP1_t$, $CBPP2_t$, $CBPP3/ABSPP_t$ and $CSPP_t$ denote indicator variables that takes the value one if ECB's asset purchase programmes (CBPP1, CBPP2, CBPP3 or ABSPP, and CSPP, respectively) were active in issuing day t (and take the value zero otherwise). In line with the strand of the literature that examines the determinants of bond spreads, $\mathbf{x}_{ismt}$ denotes a vector of contractual characteristics of bond (or bond tranche) i of category s issued by bank b in country m and day t, $\mathbf{w}_{mt}$ denotes a vector of other macroeconomic factors referent to country m in day t, and $\mathbf{v}_{bmt}$ denotes a vector of accounting and market characteristics of bank b in country m and day t. Further, u_{smc} denotes unobserved fixed effects associated to country m, which - as the coefficients - are allowed to vary with category s and period c, in line with Acharya *et al.* (2014) and attempts to control for differences across countries (e.g., legislatures and tax treatments). Finally, ε_{isbmt} denotes the error term associated to bond (or bond tranche) i of

category s issued by bank b in country m and day t.

We propose to estimate the equation above by OLS interacting each independent variable by an indicator variable that takes the value one for each combination of category s and period c. We propose also to cluster standard errors using bond tranches and years as there may be a shared component in the variation of the error term across different tranches of the same bond and across bonds issued in the same year (due to time varying risk premia). The estimates of the coefficients obtained for each combination of category s and period c will allow us to examine Hypotheses 1 and 2, respectively. The estimates of β_{1sc} and β_{2sc} will allow us to examine Hypotheses 3 and 4, respectively, for each combination of category s and period c. Finally, the estimates of β_{3sc}, β_{4sc}, β_{5sc} and β_{6sc} will allow us to examine Hypothesis 5, for each combination of category s and period c.

5. Empirical Application

5.1. Data Sources

We use four main sources of data: DCM Analytics, Datastream, S&P Global Ratings and Bankscope. DCM Analytics provides information on the spread and the contractual characteristics of bond offers, which we use as dependent and independent variables, respectively. Datastream and S&P Global Ratings provide information on the sovereign risk and macroeconomic factors of the countries of the banks that issue or originate the bonds, both of which we use as independent variables.[20] Finally, Bankscope provides information on the characteristics of the banks that issue or originate the bonds, which we also use as independent variables. As DCM Analytics and Bankscope do not have a common identification code, we hand-match the two datasets using the issuer's name for straight and covered bonds and the issuer-parent's name (originator) for securitization bonds. We perform the match at the

[20] We also make use of Datastream to supplement the information on the yield to maturity of bonds whenever that information is missing from DCM Analytics. In this case, as DCM Analytics and Datastream do not have a common identification code, we hand-match the two datasets using the issuer's name for straight and covered bonds and the issuer-parent's name (originator) for securitization bonds.

fiscal year ending just prior to the bond issuance (i.e., the closest fiscal year end in the period [–365 days to +30 days]).

5.2. Data Description

We use the information provided from the four main data sources to operationalize the concepts of the pricing equation into variables.

5.2.1. Core Variables

We begin by addressing the core variables. Table 1 provides the corresponding detailed definitions and sources, as well as the expected impact of the independent variables on the dependent variable, spread.

Spread

We follow Morgan and Stiroh (2001) and Marques and Pinto (2020) in proxying spread by the option adjusted spread (OAS): the margin yielded by the security at issue above a corresponding currency treasury benchmark with a comparable maturity. We use the OAS as it is the most common measure used by financial intermediaries to correct the normal yield spread for embedded options (e.g., the prepayment option), usually included in covered and securitization bonds. Further, considering that straight and covered bonds typically have fixed-rate coupons, whereas securitization bonds have, predominantly, floating-rate coupons (see Table 4 below), it is necessary to account, in spread computation, for the fact that the latter carries interest rate risk. To ensure comparability of spreads at issuance, we converted floating rate bonds to fixed rates using fixed-for-floating rate swaps on an individually basis (we identified the appropriate quote for the swap matching the maturity of the bond, taken at the issuance date).

Sovereign Risk

We follow Markmann and Zietz (2017) in proxying sovereign risk by the 10-year's sovereign bond yield.[21] We expect a positive impact of sovereign risk on bond spreads. Further, in

[21] As a robustness check, we consider below the sovereign credit rating from S&P as an alternative proxy, in

Table 1
Definition of Core Variables*

Variable Name	Variable Definition	Source	Exp. Impact on Credit Spread		
			Straight Bonds	Covered Bonds	Securitiz. Bonds
Dependent Variable					
Spread	Margin yielded by the security at issue above a corresponding currency treasury benchmark with a comparable maturity (OAS). Floating rate bonds were converted to fixed rates using fixed-for-floating rate swaps.	DCM Analytics and Datastream			
Independent Variables					
Sovereign Risk	10-year's sovereign bond yield of the country where the bank issuer (straight and covered bonds) or the bank originator (securitization bonds) is located.	Datastream	+	+	+
AAA	Indicator variable equal to 1 if the country where the bank issuer/originator is located has a AAA credit rating from S&P, and 0 otherwise.	S&P Global Ratings	-	-	-
CBPP1	Indicator variable equal to 1 if the bond tranche was issued from May 7, 2009 though to June 30, 2010, and 0 otherwise.	Authors	-	-	-
CBPP2	Indicator variable equal to 1 if the bond tranche was issued from October 6, 2011 though to October 31, 2012, and 0 otherwise.	Authors	-	-	-
CBPP3 / ABSPP	Indicator variable equal to 1 if the bond tranche was issued from September 4, 2014 though to December 31, 2016, and 0 otherwise.	Authors	-	-	-
CSPP	Indicator variable equal to 1 if the bond tranche was issued from March 10, 2016 though to December 31, 2016, and 0 otherwise.	Authors	-	-	-

* – denotes a negative expected impact on the credit spread while + denotes a positive expected impact on the credit spread.

order to separate the relation between banking and sovereign credit risk from the eventual implicit guarantee that governments of higher creditworthiness provide to the (domestic) banking system, we use an indicator variable that takes the value one for countries with AAA credit rating from S&P. We expect a negative relationship between this credit rating variable and bond spreads, suggesting that governments of higher creditworthiness do provide an implicit guarantee to the domestic banking system.

ECB Asset Purchase Programmes

The CBPP1 was announced on May 7, 2009, under which the Eurosystem made outright purchases of covered bonds to the nominal value of €60 billion from July 6, 2009 to June 30, 2010. On October 6, 2011, the ECB announced the CBPP2 of €40 billion in favor of euro-

the lines of Remolona *et al.* (2007). This rating is converted as follows: AAA=Aaa=1, AA+=Aa1=2 and so on until D=21.

denominated covered bonds in both primary and secondary markets. CBPP3 and ABSPP were announced on September 4, 2014. Despite initially not specified, the ECB defined later an amount of €10 billion per month (including the ABSPP). On March 10, 2016, the ECB announced the CSPP. In order to examine the impact of these asset purchase programmes on bond spreads, we include, as discussed above, four indicator variables to capture the impact of each programme, from the moment of its announcement. CBPP1 takes the value one if the bond (or bond tranche) was issued between May 7, 2009 and June 30, 2010. CBPP2 takes the value one if the bond (or bond tranche) was issued between October 6, 2011 and October 31, 2012. CBPP3/ABSPP takes the value one if the bond (or bond tranche) was issued between September 4, 2014 and December 31, 2016. Finally, CSPP takes the value one if the bond (or bond tranche) was issued between March 10, 2016 and December 31, 2016. We expect to find a significant and negative impact of the different programmes on bond spreads.

5.2.2. Control Variables

We now address the control variables. We consider the following contractual characteristics for a bond issue: credit rating, maturity, transaction size, subordination level, currency risk, price type, bank involvement, complexity and the inclusion (or not) of a call option. Further, we consider the following macroeconomic factors: the general level of interest rates, the market volatility and the yield curve slope. Finally, we consider the following accounting and market characteristics of originating/issuing banks: type, size, liquidity, performance and regulatory capital. Table 2 provides the corresponding detailed definitions and sources, as well as the expected impact of the independent variables on the dependent variable, spread. We present a more detailed description of each control variable and its expected impact on bank bond spreads in the Appendix.

Table 2
Definition of Control Variables*

Variable Name	Variable Definition	Source	Exp. Impact on Credit Spread		
			Straight Bonds	Covered Bonds	Securitiz. Bonds
Contractual Characteristics					
Rated	Indicator variable equal to 1 if the bond has a credit rating from S&P or Moody's, and 0 otherwise.	DCM Analytics	-	-	-
Rating	Bond rating based on the S&P and Moody's rating at the time of bond issuance. The rating is converted as follows: AAA=Aaa=1, AA+=Aa1=2, and so on until D=21.	DCM Analytics	+	+	+
Maturity	Bond maturity in years.	DCM Analytics	+/-	-	-
Transaction Size	Bond transaction size, converted into Euro millions when necessary.	DCM Analytics	-	-	-
Tranche to Transaction	Ratio of the bond tranche size to the bond transaction size.	DCM Analytics	+	+	+
Currency Risk	Indicator variable equal to 1 if the bond is denominated in a currency different from the currency of the country where the bank issuer/originator is located, and 0 otherwise.	DCM Analytics	+	+	+
Fixed Rate	Indicator variable equal to 1 if the bond has a fixed price, and 0 otherwise.	DCM Analytics	+	+	-
Number of Banks	The number of financial institutions participating in the bond issuance, as bookrunners, underwriters or servicers.	DCM Analytics	-	-	-
Number of Bookrunners	The number of financial institutions participating in the bond issuance as bookrunners.	DCM Analytics	+	+	+
Callable	Indicator variable equal to 1 if the bond has a call option, and 0 otherwise.	DCM Analytics	+	+	+
Macroeconomic Factors					
Risk Free Rate	The yield of the 10-year's German bunds.	Datastream	-	-	-
Market Volatility	The Chicago Board Options Exchange Volatility Index (VIX).	Datastream	+	+	+
Slope of the Swap Curve	The difference between the five-year Euro swap rate and the 3-month Libor rate.	Datastream	-	-	-
Bank Characteristics					
Total Assets	Total assets measured in Euro billion.	Bankscope	-	-	-
Loan Ratio	The ratio of net loans to total assets.	Bankscope	+	+	+
Liquid Assets to Deposits & ST Funding	The ratio of the value of liquid assets to short-term funding plus total deposits. Liquid assets include cash and due from banks, trading securities and at fair value through income, loans and advances to banks, reverse repos and cash collaterals. Deposits and short term funding includes total customer deposits and short term borrowing.	Bankscope	-	-	-
Loans to Deposits & ST Funding	The ratio of net loans to deposits and short-term funding.	Bankscope	+	+	+
Capital Ratio	The ratio of total equity to total assets.	Bankscope	-	-	-
Return on Assets	The net income divided by total assets.	Bankscope	-	-	-
Cost-to-Income Ratio	The ratio of the overheads or cost of running the bank (mostly salaries) to income generated before provisions.	Bankscope	+	+	+

* – denotes a negative expected impact on the credit spread while + denotes a positive expected impact on the credit spread.

5.3. Data Selection

We focus on bonds issued in the 2000-2016 period. We select bond issuances with a deal-type code of "corporate bond investment-grade", "corporate bond high-yield", "asset-backed security", "mortgage-backed security" and "covered bond". We require that these bonds are issued by banks located in countries from the European Economic Area plus Switzerland and that the tranche size (in € million) is available. We also require that (i) tranches have the necessary information to compute the spread, since we want to examine the pricing of these bonds and (ii) that bonds fulfil ECB's eligibility criteria for CBPP1, CBPP2, CBPP3, ABSPP and CSPP,[22] since we want to avoid a selection bias problem when evaluating the impact of those purchase programmes.

Moreover, we include only fixed rate or variable rate bonds with yield to maturity information. For variable rate bonds, only those quoted on the following indices are included: Euribor, Euro Libor, USD Libor, and GBP Libor. CDO, whole-business securitizations, perpetual bonds, and other non-straight bonds (e.g., with step-ups, caps, or floors) are excluded from the sample. With the aim of maximizing the survival rate, we use Datastream to obtain yield to maturity information for those bonds in which that information is missing in DCM Analytics. We also winsorize the data for transaction size, maturity, and spread at the 1% and the 99% levels, evaluated separately for each bond category.

The above selection screens yield a sample of 35,751 bond issuances worth €10,074 billion, of which 9,783 tranches worth €3,934.2 billion are classified as straight bonds, 15,197 tranches worth €3,465.2 billion as covered bonds, and 10,771 tranches worth €2,674.8 billion as securitization bonds. Table 3, Panel A details the tranche allocation to issuers (for straight and covered bonds) or originators (for securitization bonds) in a particular country. It reveals striking similarities between straight, covered and securitization bonds' issuance. These tranches are concentrated in six countries, with issuers located in France, Germany,

[22]For further details on the ECB's eligibility criteria for the purchase programmes, see https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html.

Italy, the Netherlands, Spain and the U.K. accounting for 88.4%, 89.5%, and 91.3% of all straight, covered, and securitization bonds issuance by volume, respectively. Two features of the data in Table 3, Panel A are noteworthy. First, covered bonds are highly concentrated in Germany. Second, securitization bonds are practically inexistent in Nordic countries.

Table 3, Panel B presents the distribution of bonds per year. It shows that the aggregated value of straight bonds' issuance peaked in 2009, dropped in 2010 and 2011 and rose again in 2012. Between 2014 and 2016, straight bond issuance by banks remained stable at around 5.5%. The issuance of securitization bonds rose significantly until 2008, reducing sharply between 2009 and 2013, coinciding with the development and the propagation of the 2008 financial crisis and the subsequent sovereign debt crisis. There is an increase in the securitization market in 2016, with more than €100 billion of tranches issued by European banks. Contrary to securitization, the covered bond market experienced a significant increase in value between 2009 and 2011, which demonstrates that there was a substitution effect between the two security types in the aftermath of the financial turmoil.

As a final note, the match with Bankscope for the characteristics of the banks that issue or originate the bonds reduced the sample substantially, from 35,751 to 15,734 bond issuances/originations (4,774 of straight bonds, 6,643 of covered bonds and 4,317 of securitization bonds).[23] Below, we address whether omitting these characteristics impacts results. We do so, by estimating the pricing equation for the full set of 35,751 bond issuances/originations and for the reduced set of 15,734 bond issuances/originations.

5.4. Summary Statistics

We now present some summary statistics of the dependent and independent variables. We begin by describing the spread, sovereign risk and contractual characteristics variables referent to the full set of 35,751 bond issuances/originations. Table 4 presents summary statistics of

[23] This match yield some extreme values for the variables referent to total assets, liquid assets to deposits & ST funding, and loans to deposits & ST funding. We trim those variables at the top and bottom 1% percentiles.

Table 3
Distribution of Bonds by Geographic Location of Issuer/Originator and Year*

	Straight Bonds			Covered Bonds			Securitiz. Bonds		
	Number of Tranches	Total Value [€ Million]	% Total Value	Number of Tranches	Total Value [€ Million]	% Total Value	Number of Tranches	Total Value [€ Million]	% Total Value
Panel A: Geographic Location of Issuer/Originator									
Austria	1,031	112,666	2.86	241	38,081	1.10	59	4,164	0.16
Belgium	257	97,198	2.47	1,007	176,254	5.09	166	46,820	1.75
Denmark	13	4,125	0.10	7	7,000	0.20	-	-	-
Finland	67	25,797	0.66	41	20,325	0.59	31	10,364	0.39
France	1,142	603,598	15.34	1,001	438,264	12.65	497	77,284	2.89
Germany	2,163	578,624	14.71	10,829	1,554,599	44.86	1,327	182,870	6.84
Greece	120	51,319	1.30	6	8,516	0.25	84	42,192	1.58
Ireland	109	75,247	1.91	57	29,638	0.86	323	61,714	2.31
Italy	1,545	537,565	13.66	730	238,120	6.87	1,073	348,682	13.04
Netherlands	854	447,948	11.39	114	60,448	1.74	1,036	387,052	14.47
Portugal	272	64,478	1.64	40	31,130	0.90	288	67,502	2.52
Spain	930	529,746	13.47	629	556,516	16.06	1,767	491,876	18.39
Sweden	7	1,980	0.05	221	51,745	1.49	-	-	-
Switzerland	24	25,713	0.65	2	1,284	0.04	-	-	-
United Kingdom	1,249	778,232	19.78	272	253,236	7.31	4,120	954,274	35.68
Total	9,783	3,934,234	100.00	15,197	3,465,156	100.00	10,771	2,674,793	100.00
Panel B: Year									
2000	585	152,768	3.88	980	211,057	6.09	352	47,876	1.79
2001	523	145,546	3.70	1,093	210,464	6.07	507	78,342	2.93
2002	622	143,071	3.64	1,300	223,134	6.44	583	90,500	3.38
2003	583	178,982	4.55	1,638	267,316	7.71	754	110,541	4.13
2004	597	212,643	5.40	1,376	235,064	6.78	779	136,955	5.12
2005	622	221,345	5.63	1,482	260,288	7.51	1,083	210,547	7.87
2006	613	285,330	7.25	1,096	274,002	7.91	1,841	311,107	11.63
2007	592	255,205	6.49	884	233,883	6.75	1,577	312,952	11.70
2008	607	280,650	7.13	1,100	246,399	7.11	894	533,871	19.96
2009	772	445,166	11.32	1,365	200,707	5.79	506	266,775	9.97
2010	751	309,279	7.86	783	221,494	6.39	221	184,785	6.91
2011	572	221,608	5.63	613	268,527	7.75	223	92,963	3.48
2012	702	244,738	6.22	432	198,466	5.73	205	81,524	3.05
2013	414	187,665	4.77	284	85,737	2.47	172	32,819	1.23
2014	383	228,087	5.80	268	98,588	2.85	263	35,630	1.33
2015	421	216,049	5.49	279	133,507	3.85	308	38,569	1.44
2016	424	206,101	5.24	224	96,522	2.79	503	109,036	4.08
Total	9,783	3,934,234	100.00	15,197	3,465,156	100.00	10,771	2,674,793	100.00

* Panel A details tranche allocation to originators/issuers in a particular country, whereas Panel B presents the distribution of tranches per year. Data are for bond tranches with spread and tranche amount available, closed by European banks during the 2000-2016 period.

those variables by bond category, considering the overall period and discriminating between two periods: a pre-crisis period, from January 1, 2000 through to September 14, 2008, and a crisis period, from September 15, 2008 (the first trading day after Lehman Brothers' bankruptcy filing) through to December 31, 2016. Table 4 also presents the outcome of Wilcoxon z-tests and Fisher's exact tests. The pair-wise comparisons indicate statistically significant differences in the means of the different variables across the sub-samples of straight, covered, and securitization bonds. This suggests that the above common pricing factors differ significantly in value between bond categories and, therefore, that we would expect the pricing equation to be category-specific.

The mean spread of straight bonds, for the overall period, is economical and statistically higher (107.91 bps) than the mean spread of covered and securitization bonds. Further, between the latter, the mean spread of covered bonds (42.56 bps) is lower than the mean spread of securitization bonds (94.37 bps). When comparing spreads among bond categories over the pre-crisis and the crisis periods, we have that: (i) the mean spread of covered bonds is lower than the mean spread of straight and securitization bonds in the two periods; and (ii) while in the pre-crisis period, securitization bonds have the highest mean spread (even compared to straight bonds), in the crisis period, the mean spread of straight bonds increased significantly vis-à-vis securitization bonds. These findings might reflect the credit risk of each bond. The mean credit rating of covered bonds (1.39 | AAA) is significantly better than the mean credit rating of straight (4.20 | AA-) and securitization (4.30 | AA-) bonds. Similar results are identified for the pre-crisis and crisis periods, with differences in spreads across categories mirroring their mean credit ratings.

Regarding sovereign risk, we have that the mean bank issuer of straight bonds is, for the full sample, located in a less riskier country than the mean bank issuer/originator of covered and securitization bonds, as the mean 10-year's sovereign bond yield for straight bond issuers (3.72%) is significantly lower than the corresponding value for covered (3.88%) and securitization (4.02%) bonds. However, significant differences arise in the analysis of the

Table 4
Summary Statistics of Spread, Sovereign risk and Contractual Characteristics*

		Overall Period			Pre-Crisis Period			Crisis Period		
		Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds
Continuous Variables										
Spread	Mean	107.91^{a,c}	42.56^{a,b}	94.37^{b,c}	33.29^{d,f}	21.64^{d,e}	76.66^{e,f}	191.17^{g,i}	91.74^{g,h}	145.55^{h,i}
	Median	74.50	29.50	64.74	31.25	19.40	57.85	147.10	73.30	106.55
Sovereign Risk	Mean	3.72^{a,c}	3.88^{a,b}	4.02^{b,c}	4.46^{d}	4.26^{d,e}	4.44^{e}	2.90^{g}	2.97^{g,h}	2.80^{h}
	Median	3.99	4.00	4.28	4.39	4.20	4.43	2.80	3.18	2.66
Rated x Rating	Mean	4.20^{a,c}	1.39^{a,b}	4.30^{b,c}	3.46^{d,f}	1.29^{d,e}	4.46^{e,f}	5.03^{g,i}	1.64^{g,h}	3.85^{h,i}
	Median	4.00	1.00	3.00	4.00	1.00	3.00	5.00	1.00	1.00
Maturity	Mean	6.30^{a,c}	5.77^{a,b}	28.21^{b,c}	6.58^{d,f}	5.58^{d,e}	27.19^{e,f}	5.99^{g,i}	6.21^{g,h}	31.14^{h,i}
	Median	5.00	5.00	31.05	5.00	4.94	29.79	5.00	5.00	32.05
Transaction Size	Mean	456.50^{a,c}	228.37^{a,b}	1,374.44^{b,c}	373.28^{d,f}	197.08^{d,e}	1,259.90^{e,f}	549.34^{g,i}	301.91^{g,h}	1,705.58^{h,i}
	Median	210.00	82.90	651.81	200.00	80.00	633.09	230.40	87.25	731.24
Tranche to Transaction	Mean	0.95^{a,c}	0.99^{a,b}	0.23^{b,c}	0.96^{d,f}	0.99^{d,e}	0.22^{e,f}	0.94^{g,i}	1.00^{g,h}	0.26^{h,i}
	Median	1.00	1.00	0.08	1.00	1.00	0.07	1.00	1.00	0.10
Number of Banks	Mean	3.61^{a,c}	1.96^{a,b}	2.49^{b,c}	3.87^{d,f}	1.89^{d,e}	2.72^{e,f}	3.32^{g,i}	2.12^{g,h}	1.85^{h,i}
	Median	2.00	1.00	2.00	2.00	1.00	2.00	2.00	1.00	1.00
Number of Bookrunners	Mean	1.81^{a,c}	1.56^{a,b}	1.51^{b,c}	1.53^{d,f}	1.43^{d,e}	1.47^{e,f}	2.12^{g,i}	1.89^{g,h}	1.60^{h,i}
	Median	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Indicator Variables										
AAA	Mean	0.68^{a,c}	0.84^{a,b}	0.76^{b,c}	0.73^{d,f}	0.88^{d,e}	0.85^{e,f}	0.62^{g,i}	0.76^{g,h}	0.52^{h,i}
	Sum	6,627.00	12,833.00	8,215.00	3,750.00	9,383.00	6,763.00	2,877.00	3,450.00	1,452.00
Rated	Mean	0.86^{a,c}	0.90^{a}	0.89^{c}	0.83^{d,f}	0.87^{d,e}	0.92^{e,f}	0.89^{g,i}	0.95^{g,h}	0.82^{h,i}
	Sum	8,420.00	13,630.00	9,628.00	4,285.00	9,317.00	7,365.00	4,135.00	4,313.00	2,263.00
Currency Risk	Mean	0.23^{a,c}	0.09^{a,b}	0.17^{b,c}	0.23^{d,f}	0.09^{d,e}	0.18^{e,f}	0.23^{g,i}	0.08^{g,h}	0.15^{h,i}
	Sum	2,252.00	1,294.00	1,863.00	1,178.00	933.00	1,440.00	1,074.00	361.00	423.00
Fixed Rate	Mean	0.70^{a,c}	0.83^{a,b}	0.08^{b,c}	0.60^{d,f}	0.84^{d,e}	0.06^{e,f}	0.81^{i}	0.81^{h}	0.16^{h,i}
	Sum	6,813.00	12,655.00	912.00	3,086.00	8,999.00	482.00	3,727.00	3,656.00	430.00
Callable	Mean	0.12^{a,c}	0.13^{a,b}	0.54^{b,c}	0.14^{d,f}	0.16^{d,e}	0.51^{e,f}	0.09^{g,i}	0.05^{g,h}	0.63^{h,i}
	Sum	1,158.00	1,963.00	5,839.00	732.00	1,723.00	4,096.00	426.00	240.00	1,743.00
N. Obs.		9,783.00	15,197.00	10,771.00	5,159.00	10,661.00	8,003.00	4,624.00	4,536.00	2,768.00

* This table reports summary statistics for the straight, covered and securitization bonds issued by the European banks in the data during the 2000-2016 period. Information on the characteristics of bond issuances was obtained from DCM Analytics and Datastream. We test for similar distributions in contractual characteristics using the Wilcoxon rank-sum test for continuous variables and the Fisher's exact test for discrete ones. a,d,g indicate significant difference at the 5% level between straight and covered bonds. b,e,h indicate significant difference at the 5% level between covered and securitization bonds. c,f,i indicate significant difference at the 5% level between straight and securitization bonds. For a definition of the variables, see Table 1 and Table 2.

pre-crisis and the crisis periods. While in the pre-crisis period, the mean bank issuer of covered bonds is located in a country with higher creditworthiness than the country of the mean issuer/originator of each of the remaining categories of bonds, after the collapse of Lehman Brothers, this role is taken by the mean originating bank of securitization bonds. This result, jointly with those obtained for the credit rating, show that in the crisis period only securitization deals with higher quality and developed by banks in less risky countries were originated.

Regarding the contractual characteristics, we find the following. First, the mean covered bond matures, for the overall period, in 5.77 years, which is a short duration if we compare it with the mean maturity of 6.30 and 28.21 years for straight and securitization bonds, respectively. A similar result is identified for the pre-crisis period, while in the crisis period this role is taken by straight bonds. Second, the mean securitization deal is characterized by a transaction size of €1,374.4 million, which is substantially higher than the mean transaction size of straight and covered bond deals (€456.5 million and €228.4 million, respectively). Further, the mean tranche to transaction ratio of securitization deals (23%) is significantly lower than the tranche to transaction ratio of straight and covered bonds deals (95% and 99%, respectively). Similar results are identified for the pre-crisis and crisis periods. Third, the number of banks participating in the issuing syndicate does provide indirect evidence that straight bond lending may be considered relatively riskier than covered and securitization lending: the mean number of banks participating in straight issues is 3.61 and is significantly higher than the means for covered and for securitization bonds (of 1.96 and 2.49, respectively). Similar results are identified for the number of bookrunners, suggesting that underwriting banks wish to increase the number of institutions participating in a straight bond issuance of a given size in order to spread risks over a larger number of banks. The statistics indicate that a larger fraction of covered bonds is issued (or originated) in countries with AAA rating (84%), have a S&P and Moody's rating (90%) and a fixed rate (83%) when compared to straight and securitization bonds. Further, the statistics indicate

that a larger fraction of straight bonds are subject to currency risk (23%) when compared to covered and securitization bonds. Finally, the statistics also indicate that a larger fraction of securitization bonds are issued with a call option (54%) when compared to straight and covered bonds.

We now describe the characteristics of the banks that issue or originate the bonds for the reduced set of 15,734 bond issuances/originations. Table 5 presents summary statistics of those variables by bond category, considering the overall period and discriminating between the pre-crisis period and the crisis period. Table 5 also presents the outcome of Wilcoxon z-tests and Fisher's exact tests.

Considering the overall period (2000-2016), the statistics presented in Table 5 yield that the mean bank that originated securitization bonds is larger, has higher loan and capital ratios and better performance (with a higher return on assets and a lower cost-to-income ratio) than the mean bank accessing straight and covered bond markets.[24] Further, the mean bank that issued covered bonds has higher liquid assets to deposits & ST funding ratios and lower loans to deposits & ST funding ratios than the mean bank that issued straight and originated securitization bonds.

The pre-crisis period is similar to the overall period, with the exception that (i) the mean bank that issued straight bonds has the highest loan ratio, (ii) the loan to deposits & ST funding ratio does not differ between banks that issued or originated covered and securitization bonds, and (iii) the capital ratio does not differ between banks that issued or originated straight and securitization bonds. The crisis period is also similar to the overall period, with the exception that total assets do not differ between banks that issued or originated straight or covered bonds and securitization bonds.

[24] The fact that mean bank that originated securitization bonds has the highest capital ratio is consistent with banks using securitization to improve capital ratios and thus benefiting from regulatory capital arbitrage (Roever and Fabozzi, 2003; Gorton and Metrick, 2013).

Table 5
Summary Statistics of Bank Characteristics*

		Overall Period			Pre-Crisis Period			Crisis Period		
		Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds
Total Assets	Mean	673.85[a,c]	530.86[a,b]	810.65[b,c]	552.10[d,f]	458.12[d,e]	804.61[e,f]	720.72[g]	593.93[g]	821.46
	Median	297.54	442.33	674.49	208.82	442.33	719.48	362.99	443.77	449.20
Loan Ratio	Mean	49.75[a,c]	43.35[a,b]	51.32[b,c]	48.86[d,f]	41.13[d,e]	46.89[e,f]	50.10[g,i]	45.28[g,h]	59.25[h,i]
	Median	52.00	43.33	54.90	53.87	40.97	52.57	51.23	45.55	60.45
Liquid Assets to Deposits & ST funding	Mean	46.51[a,c]	54.07[a,b]	42.36[b,c]	50.19[d,f]	56.26[d,e]	48.05[e,f]	45.10[g,i]	52.18[g,h]	32.17[h,i]
	Median	40.30	49.31	31.78	41.50	51.82	36.01	40.24	40.52	25.98
Loan to Deposits & ST Funding	Mean	0.98[a,c]	0.90[a,b]	0.93[b,c]	1.04[d,f]	0.87[d]	0.88[f]	0.95[g,i]	0.92[g,h]	1.02[h,i]
	Median	0.91	0.84	0.92	0.91	0.79	0.85	0.92	0.84	1.00
Capital Ratio	Mean	5.32[a,c]	3.60[a,b]	6.04[b,c]	5.52[d]	3.20[d,e]	5.70[e]	5.25[g,i]	3.95[g,h]	6.66[h,i]
	Median	5.01	3.05	5.36	5.27	2.80	5.22	4.73	3.48	5.92
Return on Assets	Mean	0.52[a,c]	0.17[a,b]	0.78[b,c]	0.93[d,f]	0.23[d,e]	0.94[e,f]	0.35[g,i]	0.12[g,h]	0.49[h,i]
	Median	0.39	0.18	0.75	0.79	0.23	0.82	0.24	0.15	0.46
Cost-to-Income Ratio	Mean	63.13[a,c]	71.96[a,b]	59.03[b,c]	57.58[d]	70.41[d,e]	57.72[e]	65.27[g,i]	73.30[g,h]	61.37[h,i]
	Median	62.35	68.09	55.47	56.49	70.78	55.33	63.40	66.93	57.35
N. Obs.		4,774.00	6,643.00	4,317.00	1,327.00	3,085.00	2,768.00	3,447.00	3,558.00	1,549.00

* This table reports summary statistics for a sample of European banks that issued straight and covered bonds and were originators in securitization bonds, during the 2000-2016 period. Information on bank specific accounting and market data was extracted from Bankscope. As DCM Analytics does not provide an identification code, we hand-matched the two databases by using the issuer's name for straight and covered bonds and the issuer-parent's name (originator) for securitization bonds. We test for similar distributions in bank characteristics using the Wilcoxon rank-sum test. a,d,g indicate significant difference at the 5% level between straight and covered bonds. b,e,h indicate significant difference at the 5% level between covered and securitization bonds. c,f,i indicate significant difference at the 5% level between straight and securitization bonds. For a definition of the variables, see Table 2.

5.5. Estimation Results

We now address the estimation results of the pricing equation, presented in Table 6. We do so, as discussed above, for the full set of 35,751 bond issuances/originations and for the reduced set of 15,734 bond issuances/originations, in order to examine if omitting the characteristics of the banks from the analysis impacts results.

5.5.1. The Full Set of Bond Issuances/Originations

We begin by considering the full set of 35,751 bond issuances/originations (excluding therefore the characteristics of the banks from the analysis), presented in Table 6, specification [1], which make use of a sample of 5,159 straight, 10,661 covered, and 8,003 securitization bonds issued (or originated) in the pre-crisis period, respectively, and 4,624 straight, 4,536 covered, and 2,768 securitization bonds issued (or originated) in the crisis period, respectively.

We begin by testing the (null) hypothesis that the coefficients of the pricing equation are equal across bond categories in each period. The results suggest that straight, covered, and securitization bonds are priced in segmented markets. We reject the null hypothesis in both periods. This validates *Hypothesis 1*. We then test the (null) hypothesis that the coefficients of the pricing equation for each bond category are equal across periods. The results suggest that the impact of the determinants on spreads is different in pre-crisis and crisis periods. We reject the null hypothesis for each bond category. This validates *Hypothesis 2*.

Having validated *Hypotheses 1* and *2*, we examine the impact of the core variables for each bond category in the two (pre-crisis and crisis) periods, separately. The results suggest, as expected, that the sovereign credit risk has a significant positive impact on the spreads of straight bonds in both pre-crisis and crisis periods. This validates *Hypothesis* 3 for straight bonds. Moreover, the results also suggest that while the sovereign credit risk has no impact on the spreads of covered bonds in the pre-crisis period, it does have a significant positive impact in the crisis period. This partially validates *Hypothesis* 3 for covered bonds and suggests that the link between sovereign and bank credit risks increases in crisis periods. Finally, while there is evidence of a significant negative impact of the sovereign risk variable on spreads for

Table 6
Estimation Results: Baseline Model*

	Full Set [1]			Reduced Set [2]		
	Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds
Pre-Crisis Period						
Sovereign Risk	15.02**	-1.87	-49.76***	9.14	3.95	-35.81
	(6.73)	(3.20)	(9.80)	(16.40)	(6.46)	(18.59)
AAA	20.00	1.25	26.88	-49.99	-12.52	287.32***
	(11.04)	(4.96)	(22.47)	(45.51)	(18.86)	(69.32)
Crisis Period						
Sovereign Risk	18.11***	25.16***	8.81	13.46***	23.44***	20.06***
	(4.65)	(2.94)	(7.07)	(4.32)	(3.42)	(5.01)
AAA	41.94***	0.45	-27.66	38.55***	-0.72	-1.39
	(7.61)	(3.96)	(20.25)	(8.58)	(4.96)	(21.73)
CBPP1	-22.15***	-30.98***	4.49	-15.74**	-30.83***	-35.23
	(6.38)	(2.36)	(21.16)	(6.72)	(2.69)	(23.55)
CBPP2	84.06***	46.36***	82.26***	72.81***	47.75***	110.24***
	(6.09)	(3.15)	(26.10)	(6.35)	(3.65)	(29.77)
CBPP3/ABSPP	-14.31	-24.30***	52.30***	-20.77**	-27.49***	88.99***
	(8.53)	(4.13)	(17.18)	(8.95)	(4.82)	(24.11)
CSPP	22.93***	21.26***	67.01***	22.62**	21.17***	90.03***
	(8.71)	(3.94)	(12.50)	(9.04)	(4.46)	(24.34)
Contr. Bond Characteristics		Yes			Yes	
Macroeconomic Factors		Yes			Yes	
Bank Characteristics		No			Yes	
Country Fixed Effects		Yes			Yes	
R-squared		0.63			0.69	
N. Obs.		35,751			15,734	
Tests of Hypotheses 1 and 2						
Pre-Crisis Period						
Straight Bonds	-	18.65***	30.92***	-	7.34***	15.40***
Covered Bonds	18.65***	-	54.54***	7.34***	-	16.06***
Securitization Bonds	30.92***	54.54***	-	15.40***	16.06***	-
Crisis Period						
Straight Bonds	-	34.34***	19.10***	-	17.09***	12.46***
Covered Bonds	34.34***	-	34.26***	17.09***	-	16.57***
Securitization Bonds	19.10***	34.26***	-	12.46***	16.57***	-
Pre-Crisis vs Crisis	38.69***	112.18***	14.48***	19.78***	41.19***	8.14***

* In specifications [1] and [2], the impact of the control variables is allowed to be specific to the bond category and the period. For specifications [1] and [2], the table presents the OLS estimation results of the pricing equation. For each independent core variable, the first row reports the estimated coefficient while the second row reports the corresponding standard errors, heteroskedasticity robust and clustered at the transaction-year level. *** and ** denote statistical significance at the 1% and 5% levels, respectively. For a definition of the variables, see Table 1. For a description of the control variables, see the Appendix.

securitization bonds in the pre-crisis period, this relationship becomes insignificant in the crisis period. This fails to support *Hypothesis 3* for securitization bonds and implies that asset-backed products, by using bankruptcy remote SPVs to hold securitized assets, based on a 'true sale' of assets by the originator to the SPV, along with the fact that credit quality assessment is based on the underlying pool of assets (Gorton and Souleles, 2007; Ayotte and Gaon, 2011), allow to mitigate the link between sovereign and bank credit risk.

Further, the results fail to support the conjecture that governments with AAA credit rating provide an implicit guarantee to domestic banking system, leading to a reduction in bond spreads, as established by *Hypothesis 4*. In contrast with Zaghini (2014), the spreads of bonds issued (or originated) by European banks in governments with AAA credit rating are not significantly different from the spreads of bonds issued (or originated) in other governments, with the exception of straight bonds in the crisis period, for which we find a significantly, but positive, difference in spreads.

Furthermore, regarding the impact of ECB's asset purchase programmes on spreads, the results are mixed. For the CBPP1, the results suggest that the programme reduced the spreads of both straight and covered bonds. This implies (i) that the programme seems to have fulfilled ECB's primary objectives of stimulating the covered bonds market and improving banks' funding conditions; and (ii) that the programme also fed through into straight bond prices. This validates *Hypothesis* 5 for these two bond categories. Further, it is consistent with Markmann and Zietz (2017) and Gürtler and Neelmeier (2018), who also find that the CBPP1 lowered the risk premiums of covered bonds. However, the results also suggest that the CBPP1 had no impact on securitization bond spreads, which fails to support *Hypothesis* 5 for such securities. For the CBPP2, the results suggest that the programme had a positive impact on the spreads of straight, covered and securitization bonds. This fails to support *Hypothesis* 5 and is consistent with Markmann and Zietz (2017) and Gürtler and Neelmeier (2018), who also find that the CBPP2 widened covered bond spreads upon its announcement. This implies that while CBPP1 has been successful in re-establishing

a functional primary covered bond market and thereby enabling banks to obtain capital market funding at a relatively low cost of borrowing, the CBPP2 has not. The reason being that it was introduced at a time of relatively sound covered bond market conditions. For the CBPP3/ABSPP, the results suggest that the two programmes reduced the spreads of covered bonds. This validates *Hypothesis* 5 for covered bonds and contrasts with Markmann (2018), who finds that the CBPP3 had no impact on the spreads of covered bonds. The results also suggest that the CBPP3/ABSPP had (i) no impact on the spreads of straight bonds and (ii) a positive impact on the spreads of securitization bonds. The reason for finding the latter positive impact may lie in the fact that, at the time of the announcement, market participants recognized that there was no need for an ABS purchase program from a bank funding perspective, as securitization bond spreads were mostly trading as tightly as in pre-crisis levels. This fails to support Hypothesis 5 for straight and securitization bonds. For the CSPP, the results suggest that this programme had a positive impact on the spreads of all bond categories, which fails to support Hypothesis 5.

5.5.2. The Reduced Set of Bond Issuances/Originations

If the credit risk of the bank is correlated with the contractual characteristics of the bond issuance/origination (and also the macroeconomic factors), the above results would be biased. In order to address this issue, we now consider the reduced set of 15,734 bond issuances/originations, which allow us to also control for the characteristics of the banks. The results are presented in Table 6, specification [2], and makes use of a sample of 1,327 straight, 3,085 covered, and 2,768 securitization bonds issued (or originated) in the pre-crisis period, respectively, and 3,447 straight, 3,558 covered, and 1,549 securitization bonds issued (or originated) in the crisis period, respectively.

As in specification [1], we begin by testing the (null) hypothesis that the coefficients of the pricing equation are equal across bond categories in each period. The results suggest that, even after controlling for the characteristics of the banks, straight, covered, and securitization bonds are priced in segmented markets. We reject the null hypothesis in both periods. This

validates *Hypothesis 1*. We then test the (null) hypothesis that the coefficients of the pricing equation for each bond category are equal across periods. The results suggest, as in model [1], that the impact of the determinants on spreads is different in pre-crisis and crisis periods. We reject the null hypothesis for each bond category. This validates *Hypothesis 2*. This implies that omitting the characteristics of the banks from the analysis does not impact the results regarding these two hypotheses.

We now address the sovereign credit risk. The results suggest that the sovereign credit risk has no impact on the spreads of straight, covered and securitization bonds in the pre-crisis period. This fails to support *Hypothesis* 3 in the pre-crisis period. Moreover, the results also suggest that the sovereign credit risk has a positive impact on the spreads of straight, covered and securitization in the crisis period. This validates *Hypothesis 3* in the crisis period and implies that (i) the link between sovereign and bank credit risk increases significantly in times of financial crisis, and (ii) controlling for bank characteristics is important.

Further, as in specification [1], the results fail to support the conjecture that governments with AAA credit rating provide an implicit guarantee to domestic banking system, leading to a reduction in bond spreads, as established by *Hypothesis 4*. In constrast with Zaghini (2014), the spreads of bonds issued (or originated) by European banks in countries with AAA credit rating are not significantly different from the spreads of bonds issued (or originated) in other countries, with the exception of securitization bonds in the pre-crisis period and straight bonds in the crisis period, for which we find a significantly, but positive, difference in spreads.

Furthermore, regarding the impact of ECB's asset purchase programmes on credit spreads, the results are, as in specification [1], mixed. Controlling for bank characteristics does not impact the results regarding the CBPP1, the CBPP2 and the CSPP. There is evidence that the CBPP1 reduced the spreads of both straight and covered bonds and had no impact on securitization bond spreads, while the CBPP2 and the CSPP had a positive impact on the spreads of straight, covered and securitization bonds. This validates *Hypothesis* 5 regarding

the impact of the CBPP1 on covered and straight bonds. Controlling for bank characteristics partly impacts the results regarding the CBPP3/ABSPP, for which there is evidence that the two programmes reduced the spreads of straight and covered bonds while increasing the spreads of securitization bonds. This validates *Hypothesis* 5 regarding the impact of the CBPP3/ABSPP on straight and covered bonds. These results suggest, once again, that controlling for bank characteristics is important.

Finally, for completeness, regarding the control variables, we find that in addition to contractual bond characteristics and macroeconomic factors, bank characteristics are also important determinants of bond spreads. We examine the estimation results related to the contractual characteristics, macroeconomic factors and bank characteristics in the Appendix.

6. Extensions

6.1. Heterogeneity Across Countries

Thus far we have assumed that the impact of the pricing determinants on bond spreads, although heterogeneous across bond categories, is homogeneous across countries. However, the literature suggests that some country heterogeneity may exist. For example, Szczerbowicz (2015), Gibson *et al.* (2016), Markmann and Zietz (2017), and Markmann (2018) find that the impact on the asset purchase programmes was stronger for the five of European periphery countries, significantly affected by the sovereign debt crisis: Greece, Ireland, Italy, Portugal, and Spain (GIIPS).[25]

In order to address this issue, we re-estimate the pricing equation for the reduced set of bonds, now issued (or originated) by banks located solely in GIIPS. The results are presented in Table 7, specification [1], and make use of a sample of 567 straight, 284 covered, and 835

[25]Markmann (2018) finds that although the CBPP1 was successful in re-establishing a functional primary covered bond market and improving financial institutions funding conditions, the effect was stronger for periphery countries. Szczerbowicz (2015) and Gibson *et al.* (2016) find that both the CBPP1 and CBPP2 induced a modest increase in the covered bond prices for GIIPS. Markmann and Zietz (2017) find that the direction and the magnitude of the impacts of the CBPP3 varied among the Eurosystem countries, leading to a tightening of spreads for Ireland and Spain, but to a widening for Germany and France.

Table 7
Estimation Results: Extensions*

	GIIPS [1]			Selection Bias [2]			Sovereign Credit Rating [3]			Additional Bank Characteristics: [4]		
	Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds
Pre-Crisis Period												
Sovereign Risk	121.40***	95.25***	-25.10	9.51	9.67	-36.13	-9.51	-8.66	-156.75***	12.02	-4.80	-47.87**
	(28.22)	(17.53)	(47.51)	(16.69)	(7.22)	(19.02)	(11.15)	(9.16)	(49.55)	(22.51)	(7.97)	(21.08)
AAA	-129.84**	-71.84	29.74	-46.39	-29.39	293.49***	-26.64	0.59	379.81***	-88.03	5.20	320.16***
	(56.18)	(83.47)	(121.55)	(49.06)	(19.99)	(81.99)	(26.01)	(13.71)	(87.17)	(65.72)	(31.41)	(87.27)
Crisis Period												
Sovereign Risk	7.22	13.14***	21.07***	13.61***	23.53***	20.11***	3.97**	-3.00***	16.44***	13.30***	23.01***	18.70***
	(3.71)	(4.26)	(5.56)	(4.27)	(3.73)	(7.70)	(1.84)	(1.02)	(4.53)	(4.27)	(3.50)	(5.58)
AAA	-11.55	-73.29***	1.70	38.65***	-0.68	-1.56	35.90***	-23.38***	-9.54	33.30***	-2.41	9.53
	(17.80)	(9.59)	(37.49)	(8.10)	(4.85)	(24.22)	(8.62)	(4.81)	(20.96)	(9.62)	(5.51)	(22.29)
CBPP1	-25.33**	-44.32***	17.38	-16.16**	-31.07***	-35.50	-19.13***	-30.77***	-33.48	-11.11	-32.25***	-64.35***
	(12.05)	(9.80)	(17.59)	(7.69)	(2.74)	(23.59)	(6.76)	(2.73)	(23.68)	(7.16)	(2.94)	(22.29)
CBPP2	121.50***	27.11***	-13.78	72.18***	47.23***	110.10***	80.39***	59.02***	115.90***	70.25***	48.11***	141.18***
	(17.34)	(10.14)	(38.75)	(6.78)	(3.92)	(31.23)	(6.34)	(3.60)	(29.79)	(6.66)	(3.81)	(30.44)
CBPP3/ABSPP	-96.37***	-85.56***	42.48	-21.89***	-28.69***	87.98***	-30.70***	-49.11***	61.32**	-19.53**	-29.14***	87.08***
	(20.76)	(15.08)	(32.21)	(7.68)	(4.73)	(27.45)	(7.99)	(4.11)	(24.84)	(9.39)	(5.02)	(24.34)
CSPP	21.31	-18.63	141.80***	21.84**	20.41***	89.29***	22.02**	14.80***	77.83***	23.88**	22.98***	97.08***
	(25.20)	(13.19)	(38.75)	(8.93)	(4.23)	(29.74)	(9.14)	(4.58)	(23.53)	(9.71)	(4.71)	(24.65)
ρ					-0.15							
Adj. R-squared		0.72						0.69			0.71	
N. Obs.		7,973			14,100 (no spread) 15,734 (spread)			15,734			13,432	
Tests of Hypotheses 1 and 2												
Pre-Crisis Period												
Straight Bonds	-	5.78***	3.19***	-	766.60***	1540.63***	-	7.74***	16.29***	-	5.33***	8.18***
Covered Bonds	5.78***	-	3.34***	766.60***	-	2587.59***	7.74***	-	16.47***	5.33***	-	13.73***
Securitiz Bonds	3.19***	3.34***	-	1540.63***	2587.59***	-	16.29***	16.47***	-	8.18***	13.73***	-
Crisis Period												
Straight Bonds	-	9.56***	12.05***	-	1846.51***	789.55***	-	16.92***	12.78***	-	15.00***	10.58***
Covered Bonds	9.56***	-	7.83***	1846.51***	-	1842.57***	16.92***	-	16.34***	15.00***	-	14.10***
Securitiz Bonds	12.05***	7.83***	-	789.55***	1842.57***	-	12.78***	16.34***	-	10.58***	14.10***	-
Pre-Crisis vs Crisis	16.17***	8.73***	2.56***	3490.72***	9833.43***	905.48***	20.19***	39.64***	8.18***	15.15***	32.36***	7.92***

* Specifications [1] to [4] include contractual bond characteristics, macroeconomic factors, bank characteristics and country fixed effects as controls. Specification [4] includes the capital adequacy ratio and the non-performing loans ratio as additional controls. In specifications [1] to [4], the impact of the control variables is allowed to be specific to the bond category and the period. For specifications [1], [3] and [4], the table presents the OLS estimation results of the pricing equation while for specification [2] the table presents the estimation results of the pricing equation using Heckman (1979) procedure. For each independent core variable, the first row reports the estimated coefficient while the second row reports the corresponding standard errors, heteroskedasticity robust and clustered at the transaction-year level. *** and ** denote statistical significance at the 1% and 5% levels, respectively. For a definition of the variables, see Table 1. For a description of the control variables, see the Appendix.

securitization bonds issued (or originated) in the pre-crisis period and 947 straight, 653 covered, and 630 securitization bonds issued (or originated) in the crisis period.[26]

The results suggest that (i) straight, covered, and securitization bonds issued (or originated) in GIIPS are priced in segmented markets and (ii) the impact of the determinants on spreads issued (or originated) in GIIPS is different in pre-crisis and crisis periods. This validates *Hypotheses 1* and *2*. These results suggest that the GIIPS are not significantly different from the remaining countries regarding these two hypotheses. As a consequence, we now examine the impact of the core variables for each bond category in the two (pre-crisis and crisis) periods, separately.

The results suggest that the sovereign credit risk has, in the pre-crisis period, (i) a positive impact on the spreads of both straight and covered bonds, and (ii) no impact on the spreads of securitization bonds. This validates *Hypothesis* 3 for straight and covered bonds in the pre-crisis period, suggesting that the relationship between sovereign and bank credit risks is stronger in the GIIPS in the pre-crisis period in comparison with the remaining European countries. Moreover, the results also suggest that the sovereign credit risk has, in the crisis period, (i) no impact on the spreads of straight bonds, and (ii) a positive impact on the spreads of both covered and securitization bonds. This validates *Hypothesis 3* for covered and securitization bonds in the crisis period, suggesting that the relationship between sovereign and bank credit risks in the GIIPS is different from the remaining European countries also in the crisis period.

Further, the results also suggest that GIIPS governments with AAA credit rating provide, in both periods, partial implicit guarantee to domestic banking system and, consequently, are partly different from the remaining European countries regarding *Hypothesis 4*. In the pre-crisis period, the spreads of bonds issued (or originated) by banks in GIIPS with AAA credit rating are (i) lower than the spreads of bonds issued (or originated) in GIIPS with

[26] In this extensions section, we control for the characteristics of the banks, since the results in Table 6 suggest those controls are important. The results for the cases in which we exclude the characteristics of the banks from the analysis are, naturally, available upon request.

other ratings for straight bonds, and (ii) not significantly different from the spreads of bonds issued (or originated) in GIIPS with other ratings for covered and securitization bonds. This partially supports *Hypothesis 4* for straight bonds. In the crisis period, the spreads of bonds issued (or originated) by banks in GIIPS with AAA credit rating are (i) lower than the spreads of bonds issued (or originated) in GIIPS with other ratings for covered bonds, and (ii) not significantly different from the spreads of bonds issued (or originated) in GIIPS with other ratings for straight and securitization bonds. This partially supports *Hypothesis 4* for covered bonds.

Finally, regarding the impact of ECB's asset purchase programmes on spreads, the results are also mixed for the GIIPS . For the CBPP1, the results suggest that the programme (i) reduced the spreads of both straight and covered bonds, and (ii) had no impact on the spreads of securitization bonds. This partially supports *Hypothesis 5* for straight and covered bonds. Moreover, the estimated magnitude of the reduction in the spreads of both straight and covered bonds is higher than those estimated for the remaining European countries, which implies that the impact of the CBPP1 on banks' funding conditions was greater for banks located in countries severely affected by the sovereign debt crisis. For the CBPP2, the results suggest that the programme (i) had a positive impact on the spreads of straight and covered bonds, and (ii) had no impact on the spreads of securitization bonds. This fails to support *Hypothesis 5*. Moreover, this implies that the programme has not fulfilled ECB's primary objectives of improving banks' funding conditions even for those banks located in the GIIPS. For the CBPP3/ABSPP, the results suggest that the two programmes (i) reduced the spreads of straight and covered bonds, and (ii) had no impact on the spreads of securitization bonds. This partially supports *Hypothesis 5* for straight and covered bonds. Further, as for the CBPP1, the estimated magnitude of the reduction in the spreads of both straight and covered bonds is higher than those estimated for the remaining European countries. For the CSPP, the results suggest that the programme (i) had no impact on the spreads of straight and covered bonds, and (ii) had a positive impact on the spreads of securitization

bonds. This fails to support *Hypothesis* 5. These results suggest that the impact of ECB's asset purchase programmes on the spreads of bonds issued (or originated) in the GIIPS is significantly different from the remaining European countries.

6.2. Selection Bias

Thus far we have been using bond issuances that have the necessary information to compute the spread. This induces a significant reduction in the sample, which in turn raises the issue of whether bonds with the necessary information to compute the spread are or not different from those with missing information. If the probability of observing the necessary information to compute the spread is not random, our (previous) estimates will be biased. In order to address this issue, we estimate the following Heckman (1979)'s two-stage selection model. In the first stage, we model the selection of bond issuances included in the sample. We consider that the lack of the necessary information to compute the spread of a bond issuance can arise: (i) if there is no treasury benchmark with a comparable maturity, or (ii) from a clerical error by DCM Analytics. As such, we make use of the following standard probit model:

$$spread^{*}_{isbmt} = \alpha_0 + \alpha_1 mat_{isbmt} + \boldsymbol{\theta}\mathbf{z}_{isbmt} + \eta_{isbmt} \tag{2}$$

$$I_{isbmt} = \begin{cases} 1 & \text{if } spread^{*}_{isbmt} > 0 \\ 0 & \text{otherwise,} \end{cases}$$

where $spread^{*}_{ismt}$ denotes an unobservable latent variable associated to bond (or bond tranche) i of category s issued by bank b in country m and day t, mat_{isbmt} denotes the maturity of bond (or bond tranche) i of category s issued by bank b in country m and day t, $\mathbf{z}_{bmt}$ denotes denotes a vector of determinants of the clerical errors made by DCM Analytics in recording the characteristics of the bond issuances of bank b in country m and day t, η_{isbmt} denotes the error term associated to bond (or bond tranche) i of category s issued by bank b in country

m and day t, and finally I_{isbmt} denotes an indicator variable that takes the value one if bond (or bond tranche) i of category s issued by bank b in country m and day t has the necessary information to compute the spread (and takes the value zero otherwise).

In the second stage, we estimate our (previous) reduced-form pricing model using the bonds issuances that have the necessary information to compute the spread:

$$\begin{aligned} spread_{isbmt} &= \beta_{1sc} SR_{mt} + \beta_{2sc} AAA_{mt} + \beta_{3sc} CBPP1_t + \beta_{4sc} CBPP2_t \\ &\quad + \beta_{5sc} CBPP3/ABSPP_t + \beta_{6sc} CSPP_t + \boldsymbol{\gamma}_{sc} \mathbf{x}_{isbmt} + \boldsymbol{\varphi}_{sc} \mathbf{w}_{mt} \\ &\quad + \boldsymbol{\delta}_{sc} \mathbf{v}_{bmt} + u_{smc} + \varepsilon_{isbmt}. \end{aligned} \tag{3}$$

Finally, we assume that the error terms η_{isbmt} and ε_{isbmt} are jointly normally distributed, as follows:

$$\begin{bmatrix} \eta_{isbmt} \\ \varepsilon_{isbmt} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & \sigma \end{bmatrix} \right), \tag{4}$$

where ρ denotes the correlation between the error terms, which controls the degree to which the sample selection biases the estimates of the pricing equation.

We estimate the two stages using Heckman (1979)'s procedure.[27] We begin by using the set of all bond issuances/originations (with and without spread information) to estimate, by maximum likelihood, the standard probit model in the first (selection) stage. This makes use of a sample of 10,394 straight (9,067 with no spread and 1,327 with spread), 3,783 covered (698 with no spread and 3,085 with spread), and 4,183 securitization bonds (1,415 with no spread and 2,768 with spread) issued (or originated) in the pre-crisis period and 4,731 straight (1,284 with no spread and 3,447 with spread), 3,973 covered (415 with no spread and 3,558 with spread), and 2,770 securitization bonds (1,221 with no spread and

[27] We do so to avoid the convergence problems that may arise from a full information maximum likelihood procedure.

1,549 with spread) issued (or originated) in the crisis period. We consider the following determinants of clerical errors by DCM Analytics in recording the characteristics of bond issuances: (i) the number of issuances recorded in each year, overall and by bank; (ii) the number of bonds recorded in each year, overall and by bank; and (iii) a trend (to capture economies of experience and technological changes in DCM Analytics). We use the estimates of the first stage to compute the inverse Mills ratio for each bond issuance, which we then include as an additional explanatory variable of the second stage's pricing equation (the coefficient associated to this additional explanatory variable is $\rho\sigma$). We use the set of 15,734 bond issuances/originations with spread information to estimate the (augmented) pricing equation by OLS and test the null hypothesis that $\rho = 0$. The results, presented in Table 7, specification [2] suggest that the selection of bond issuances and pricing are independent, which implies that our (previous) estimates are not biased by sample selection issues.

6.3. Robustness Checks

Thus far we have been following Markmann and Zietz (2017) in proxying sovereign risk by the 10-year's sovereign bond yield. As a robustness check, we use the sovereign credit rating (at close) from S&P, obtained from S&P Global Ratings, as an alternative proxy, in the lines of Remolona *et al.* (2007).[28] To do so, we make use of the set of 15,734 bond issuances/originations. The results, presented in Table 7, specification [3], seem robust to this alternative proxy, with two exceptions. We now find, as in Table 6, specification [1], a negative impact of the sovereign credit risk on the spreads of securitization bonds in the pre-crisis period. This result can be explained by the fact that securitization securities are usually designed - namely in terms of asset pool, subordination and other credit enhancement mechanisms, covenants, warranties, governance structure, and trusts - to achieve segregation of the pool of assets or cash flows, from the originator of the transaction, which mitigates the link between sovereign and bank credit risk. In addition, we find a negative impact of the

[28]This rating is converted as follows: AAA=Aaa=1, AA+=Aa1=2 and so on until D=21.

sovereign credit risk (and of AAA sovereign credit rating) on the spreads of covered bonds in the crisis period, which can result from the fact that sovereigns with higher credit rating downgrades, in the crisis period, were also the ones that benefited the most from ECB's covered bond purchase programmes. Overall, we interpret these results as corroborating the option of proxying sovereign risk by the 10-year's sovereign bond yield.

Furthermore, thus far, when we control for the characteristics of the banks, we have been (i) proxying the regulatory capital of the bank solely by the capital ratio and (ii) not directly controlling for the credit risk of the bank. As a robustness check, we now proxy the regulatory capital of the bank by an additional control, obtained from Bankscope: the capital adequacy ratio, measured as the Tier 1 + Tier 2 capital, which includes subordinated debt, hybrid capital, loan loss reserves and valuation reserves, as a percentage of risk-weighted assets and off-balance sheet risks. We expect this proxy to have a negative impact on spreads. Moreover, we now also control for the credit risk of the bank, proxied by the non-performing loans ratio, obtained from Bankscope and measured as the ratio of total non-performing (or doubtful) loans to gross loans, which we expect to have a positive impact on spreads. We have not included these additional controls in the main analysis because they reduce significantly the sample. The results are presented in Table 7, specification [4] and make use of a sample of 898 straight, 2,646 covered, and 2,213 securitization bonds issued (or originated) in the pre-crisis period and 3,184 straight, 3,143 covered, and 1,348 securitization bonds issued (or originated) in the crisis period. Overall, the results seem robust to these additional controls, with three exceptions. We find: (i) as in specification [3], a negative impact of the sovereign credit risk on the spreads of securitization bonds in the pre-crisis period, (ii) no impact of the CBPP1 on the spreads of straight bonds, since this impact may now be fully captured via the capital adequacy ration and the non-performing loans ratio, and (iii) a negative impact of the CBPP1 on the spreads of securitization bonds, which suggests that the CBPP1 has been successful in lowering spreads also for such securities.

7. Conclusions

The 2008 Global financial crisis and the subsequent European sovereign debt crisis deteriorated banks funding conditions, dried up debt markets, and lead to a substitution effect among bond instruments. This article examines the pricing of straight, covered and securitization bonds issued by European banks in the 2000-2016 period, with a particular focus on the interdependence between sovereign and bank credit risk and on the impact of ECB's asset purchase programmes on spreads.

We find that straight, covered, and securitization bonds are priced in segmented debt markets and that the impact of common pricing factors on spreads differ significantly between the pre-crisis and the crisis periods. We find also that contractual bond characteristics other than credit ratings, macroeconomic factors and bank characteristics are important determinants of bond spreads. These results provide issuing banks with instrumental information to select among the three core debt market funding alternatives and, thereby, lower refinancing costs, particularly during crisis periods. These results provide also bond investors (e.g., the ECB which holds a significant amount of covered and securitization bonds as a consequence of the recent asset purchase programmes) with instrumental information to manage risk.

Further, the results also suggest that while sovereign credit risk is not an important variable in determining banks cost of funding in the pre-crisis period, it is so in the crisis period, for which we find a positive relationship between sovereign credit risk (proxied by the 10-year's sovereign bond yields) and the spreads of straight, covered and securitization bonds. These results contribute to the ongoing policy debate regarding the drivers of bank exposures to sovereign risk.

Finally, we find that bond markets respond efficiently to asset purchase programmes when there is a clear rationale for central bank intervention (in line with Markmann, 2018). In particular, we find that the CBPP1 eased bank funding conditions (through the emission of both straight and covered bonds), which suggests that this programme was successful. We find also that the CBPP2 not only lead to an increase in the spreads of covered bond, but also

fed through into other securities, widening the spreads of straight and securitization bonds. This may reflect the fact that market participants largely expected the programme or that it was not equipped to solve the prevalent sovereign debt crisis. We find also that while the CBPP3/ABSPP was successful in reducing the spreads of (straight and) covered bonds, the purchase of asset-backed securities did not reduce securitization bond spreads. Moreover, the CSPP fed through into securitization bonds, increasing spreads. These results suggest that the unconventional monetary policy measures taken during the sovereign debt crisis, with the exception of the CBPP3 for straight and covered bonds, had a limited impact on the bond markets, particularly in allowing banks to issue debt at lower funding costs. Further, they also contribute to the discussion on how effective the tools created for 2008 Global financial crisis (and the subsequent European sovereign debt crisis) have proven to be and how they may be implemented in response to the COVID-19 pandemic and future crises.

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Appendix

In this appendix, we (i) detail the control variables (contractual characteristics of bonds, macroeconomic factors, characteristics of the banks) included in the analysis of the main text and their expected impact on bank bond spreads, and (ii) examine the estimation results corresponding to Table 6, specification [2] related to their empirical impact on bank bond spreads.

A.1 Control Variables

A.1.1 Contractual Characteristics

We consider the following contractual characteristics for a bond issue: credit rating, maturity, transaction size, subordination level, currency risk, price type, bank involvement, complexity and the inclusion (or not) of a call option.

Credit rating is a central determinant of the spread of straight bonds (Collin-Dufresne *et al.*, 2001; Elton *et al.*, 2001; Hull *et al.*, 2004; Titman *et al.*, 2004; Longstaff *et al.*, 2005) and securitization bonds (Marques and Pinto, 2020).[29] In order to examine the impact of the credit rating on spreads, we use two variables. First, we use an indicator variable that takes the value one if the bond (or bond tranche) has a credit rating from S&P and/or Moody's (and takes the value zero otherwise). It controls for the fact that some securitization bonds, namely equity tranches, are not rated. Second, we use the credit rating of those bonds (or bond tranches) that are rated by S&P or Moody's. Following Cornaggia *et al.* (2017) this rating is converted as follows: AAA=Aaa=1, AA+=Aa1=2 and so on until D=21. If a bond (or bond tranche) has two credit ratings, we compute the average. Rating scales are inverse scales, so we expect spreads to increase as rating decreases (and the rating scale increases).

Maturity is also an import determinant of the spread of bonds. Bonds with longer maturities typically pay higher yields vis-à-vis comparable bonds with shorter maturities. Empirical

[29] Marques and Pinto (2020) find that the importance of credit ratings in securitization bonds seems to be far greater than in straight bonds.

evidence regarding the impact of maturity on spreads of straight bonds is somehow controversial. Jones *et al.* (1984), Sarig and Warga (1989), and Gabi and Sironi (2005) argue that the term structure of spreads for investment grade bonds is upward-sloping, while Fons (1987), Sarig and Warga (1989), and Helwege and Turner (1999) show different results for non-investment grade bonds. Regarding covered bonds, the covered pool of assets in bonds with higher maturities are mortgages, which have, typically, lower credit risk.[30] Regarding securitization bonds, the literature suggests that the impact of maturity on spreads is negative (Vink and Thibeault, 2008) and non-linear (Marques and Pinto, 2020). We expect to find a positive impact on bond spreads for straight bonds and a negative relationship for covered and securitization bonds.

The transaction size of a bond is also an import determinant of the spread of bonds. In particular, larger transaction sizes are, *ceteris paribus*, positively related with lower uncertainty and higher liquidity than smaller offerings for straight bonds (Gabbi and Sironi, 2005; Chen *et al.*, 2007; Sorge and Gadanecz, 2008), covered bonds (Prokopczuk and Vonhoff, 2012; Prokopczuk *et al.,* 2013) and securitization bonds (Vink and Thibeault, 2008). We thus expect larger issuances to exhibit lower spreads.

The subordination level is also an import determinant of bond spreads. In securitization bonds, the structure is layered so that each position benefits from the credit protection of all the positions subordinated to it. For example, each senior class (or tranche) has absolute priority in the cash flow over the more junior classes and junior classes are typically smaller than senior ones. We use the tranche to transaction ratio as a proxy of the subordination level. We expect a negative impact of this ratio on the spread for securitization bonds, but a positive relationship for straight and covered bonds – since in those cases issuances with higher tranche to transaction ratios are generally seen as riskier in that the transaction has to be split into several tranches for risk spreading.

[30] Gibson *et al.* (2016) document also that, for covered bonds, the effectiveness of the ECB's asset purchase programmes varies with the bonds time to maturity.

Finally, currency risk, price type, bank involvement, complexity and the inclusion (or not) of a call option are also important determinants of the spread of bonds. We control for currency risk using an indicator variable that takes the value one if the bond (or bond tranche) is denominated in a currency different from the currency of the country where the bank issuer/originator is located. Following Fabozzi and Vink (2012) and Gürtler and Neelmeier (2018), we expect bonds exposed to currency risk to have higher spreads than those that are not. We control for price type using an indicator variable that takes the value one if the bond (or bond tranche) has a fixed price. Following Sorge and Gadanecz (2008), we expect issuers to raise funds at a higher spreads through fixed priced issues than through floating priced issues. We control for bank involvement by the number of banks supporting the transaction and, following Sufi (2007), we expect a negative relationship with spreads. We control for the complexity of the transaction (and additional differences in bank syndicates) by the number of bookrunners. As a higher number of bookrunners may reflect a greater complexity of the transaction, we expect a positive impact on spreads. Finally, we control for the inclusion (or not) of a call option using an indicator variable that takes the value one if the bond has a call option and expect that callable bonds have higher spreads.

A.1.2 Macroeconomic Factors

We consider the following macroeconomic factors: the general level of interest rates, the market volatility and the yield curve slope. We proxy the general level of interest rates and the market volatility by the risk free rate (computed as the yield of the 10-year German bunds) and the Chicago Board Options Exchange Volatility Index, respectively. We estimate the yield curve slope as the difference between the five-year Euro swap rate and the 3-month Libor rate. For the three bond categories, we expect that increases in market volatility should have a positive impact on spreads, while an opposite effect is expected for the level of interest rates and the yield curve slope.

A.1.3 Characteristics of the Originating/Issuing Banks

We consider the following accounting and market characteristics of originating/issuing banks: type, size,[31] liquidity, performance and regulatory capital, in line with the literature that examines the motivations for financial firms using securitization (Affinito and Tagliaferri, 2010; Cardone-Riportella *et al.*, 2010; Farruggio and Uhde, 2015) and the literature that examines the relation between sovereign and bank credit risks (De Bruyckere *et al.*, 2013; Acharya *et al.*, 2014; Zaghini, 2014; Li and Zinna, 2018).

We proxy the type of bank and the size of the bank by the loan ratio and the natural logarithm of total assets, respectively. We proxy the liquidity of the bank by (i) the ratio of liquid assets to deposits & ST funding and (ii) the ratio of loans to deposits and ST funding. We proxy the performance of the bank by (i) the return on assets and (ii) the cost-to-income ratio. Finally, we proxy the regulatory capital of the bank by the capital ratio. We expect a negative impact of the total assets, return on assets, liquid assets to deposits & ST funding, and capital ratio variables, on spreads, but a positive relationship between loan ratio, loans to deposits and ST funding, and cost-to-income ratio and spreads.[32,33]

A.2 Estimation Results

Table A1 presents the estimation results corresponding to Table 6, specification [2] related to the impact of the contractual characteristics of bonds, the macroeconomic factors, and the characteristics of the banks on bond spreads.

Regarding the contractual characteristics of bonds, the results suggest the following. The impact of credit risk on spreads is in line with expectations. Conditional on having a credit rating, the higher the credit risk of the bond, the higher the spread, for all bond categories

[31] Size measures the Too big to Fail (TBTF) problem (Acharya and Rajan, 2013; Acharya *et al.*, 2014; Zaghini, 2014).

[32] As a robustness check, we also control for the credit risk of the bank, proxied by the non-performing loans ratio. We expect this proxy to have a positive impact on spreads.

[33] As a robustness check, we also proxy the regulatory capital of the bank by the capital adequacy ratio. We expect this proxy to have a negative impact on spreads.

and both periods (with the exception of straight bonds in the pre-crisis period, for which we find no impact). For example, AA+ bonds are estimated to have spreads 19.14 bps, 1.35 bps, and 15.11 bps higher than AAA bonds for straight, covered, and securitization issues in the crisis period, respectively.

Maturity seems to have a positive impact on the spreads of the three categories of bonds in the pre-crisis period, in line with Fons (1987) and Helwege and Turner (1999). Further, the results also suggest that, in the crisis period, maturity has (i) a positive impact on the spreads of straight bonds, (ii) a negative impact on the spreads of covered bonds, and (iii) no impact on the spreads of securitization bonds.

Transaction size seems to have no impact on the spreads of straight and covered bonds in the pre-crisis period and a positive impact in the crisis period. The reason for this finding may lie in the lower capacity of investors to constitute larger shares of bonds in their portfolios in periods of crisis. Further, the results also suggest a negative impact on the spreads of securitization bonds in both periods. This implies a positive price liquidity effect related to the size of the transaction.

The tranche to transaction ratio seems not to impact the spreads of straight bonds in both periods. This implies that tranching seems not to impact spreads of straight bonds. Further, the results also suggest no impact on the spreads of covered bonds in the pre-crisis period and a positive impact in the crisis period. Furthermore, the results also suggest a positive impact on the spreads of securitization bonds in the pre-crisis period and no impact in the crisis period.

The currency risk seems to have in the pre-crisis period (i) a positive impact on the spreads of straight and covered bonds and (ii) a negative impact on the spreads of securitization bonds. Further, the results also suggest a positive impact on the spreads of the three categories of bonds in the crisis period.

Straight and covered bonds with a fixed rate have (as expected) higher spreads than those with a floating rate, in both periods. Further, while the results suggest no difference, in the

pre-crisis period, between the spreads of securitization bonds involving fixed and floating rates, in the crisis period the spreads of securitization bonds involving a fixed rate are lower than those with a floating rate. This latter result is consistent with Marques and Pinto (2020), who find that issuers raise funds via securitization at lower spreads through fixed priced issues than through floating rate issues.

The number of banks involved in a bond issuance seems not to impact the spreads of the three categories of bonds in both periods, with the exception of securitization bonds in the pre-crisis period, for which we find a negative impact. These results may reflect the outcome of two opposing effects. On the one hand, a high number of banks involved may reflect riskier bond issuances in the sense that the banks seek to spread the risk. On the other hand, a high number of banks involved may signal to investors a greater certification of the transaction. The two effects seem to balance for the three categories of bonds in both periods, with the exception of securitization bonds in the pre-crisis period, for which the second effect seems to dominate.

The number of bookrunners seems not to impact the spreads of the three categories of bonds in both periods, with the exception of straight bonds in the pre-crisis period and of covered bonds in the crisis period, for which we find a positive and negative impact, respectively. This implies that investors, in general, do not demand a higher yield for more complex transactions that require a higher number of bookrunners.

Finally, the results suggest no difference in the spreads of the three categories of bonds involving or not a call option in the pre-crisis period. Further, the results also suggest, in the crisis period, (i) that straight and covered bonds with a call option have higher spreads than those without such option, and (ii) no difference between the spreads of securitization bonds involving or not a call option.

Regarding the macroeconomic factors, the results suggest the following. The risk free rate seems to have (i) no impact on the spreads of straight and covered bonds in the pre-crisis period, (ii) a negative impact on the spreads of straight and covered bonds in the crisis period

Table A1
Estimation Results Reduced Set of Bond Issuances: Control Variables*

	Pre-Crisis Period			Crisis Period		
	Straight Bonds	Covered Bonds	Securitiz Bonds	Straight Bonds	Covered Bonds	Securitiz Bonds
Contractual Bond Characteristics						
Rated	-20.81	0.81	-82.69***	-108.23***	5.53	-83.12***
	(15.47)	(3.64)	(29.38)	(11.24)	(3.30)	(18.18)
Rated x Rating	1.84	1.66**	18.93***	19.14***	1.35**	15.11***
	(1.66)	(0.67)	(0.98)	(1.25)	(0.64)	(1.54)
Maturity	1.94**	0.98***	0.53**	2.52***	-0.56**	-0.92
	(0.94)	(0.32)	(0.26)	(0.77)	(0.24)	(0.56)
Log Transaction Size	-3.32	-0.43	-10.41***	6.89***	4.41***	-34.50***
	(2.35)	(0.69)	(4.04)	(1.78)	(0.78)	(7.51)
Tranche to Transaction	7.41	13.11	26.61***	2.11	56.49**	-10.53
	(12.31)	(7.91)	(8.60)	(19.99)	(28.08)	(15.72)
Currency Risk	19.74***	13.39***	-42.98***	17.98**	11.60**	64.74***
	(6.78)	(3.01)	(10.34)	(7.45)	(5.21)	(20.44)
Fixed Rate	12.80**	5.78***	-50.92	49.08***	18.86***	-72.76***
	(5.02)	(1.88)	(30.72)	(4.84)	(2.27)	(25.72)
Number of Banks	0.14	-0.42	-3.44**	-0.36	0.78	2.96
	(0.68)	(0.27)	(1.51)	(0.56)	(0.82)	(7.65)
Number of Bookrunners	15.60***	0.57	0.80	0.48	-2.83**	-4.95
	(2.58)	(0.39)	(4.04)	(1.80)	(1.17)	(9.41)
Callable	11.66	3.33	11.36	57.02***	14.27***	-5.61
	(8.76)	(4.27)	(6.39)	(11.16)	(4.96)	(13.25)
Macroeconomic Factors						
Risk Free Rate	-8.46	3.91	35.57***	-27.97***	-18.71***	28.00**
	(12.45)	(4.83)	(13.54)	(5.84)	(3.21)	(12.51)
Market Volatility	2.90***	0.80***	1.66**	1.50***	1.14***	-1.17**
	(0.64)	(0.19)	(0.82)	(0.23)	(0.10)	(0.58)
Shape of the Swap Curve	-0.55***	-0.23***	-0.18	-0.05	-0.11***	0.20
	(0.16)	(0.06)	(0.19)	(0.06)	(0.04)	(0.18)
Bank Characteristics						
Log Total Assets	4.92***	-0.41	5.78**	-9.92***	-2.03**	10.75***
	(1.23)	(0.85)	(2.61)	(1.70)	(0.97)	(4.19)
Loan Ratio	-0.07	-0.06	-1.08***	-0.50**	0.02	0.28
	(0.20)	(0.15)	(0.39)	(0.24)	(0.14)	(0.66)
Liquid Assets to Deposits & ST Funding	0.01	-0.03	-0.57***	-0.50***	-0.08***	0.29
	(0.10)	(0.05)	(0.16)	(0.14)	(0.03)	(0.35)
Loans to Deposits & ST Funding	2.08	4.57	20.37***	10.70**	5.01	-1.27
	(2.82)	(3.10)	(7.93)	(4.45)	(3.62)	(19.65)
Capital Ratio	0.37	-1.44	-1.71	-1.51	0.59	0.43
	(0.65)	(0.94)	(1.71)	(1.34)	(0.99)	(1.25)
Return on Assets	0.63	3.39	3.55	4.52	-1.31	38.68**
	(3.06)	(4.48)	(7.96)	(4.01)	(2.89)	(15.14)
Cost-to-Income Ratio	0.49**	0.07	-0.64	0.49***	0.08**	0.84***
	(0.21)	(0.09)	(0.38)	(0.13)	(0.03)	(0.29)

* Please see Table 6 for the details on the data, the estimation procedure and the reported results.

(which is consistent with the empirical literature that examines the relationship between the level of interest rates and spreads), and (iii) a positive impact on the spreads of securitization bonds in both periods.

Market volatility seems to have a positive impact on the spreads of the three categories of bonds in both periods, with the exception of securitization bonds in the crisis period, for which we find a negative impact. The reason for the latter exception may lie in fact that in times of higher market volatility securitization structures, by means of asset segregation and collateralization and security design mechanisms - namely in terms of asset pool, tranches, covenants, warranties, governance structure, and trusts - are interesting instruments for banks to raise debt with relatively lower spreads.

Finally, the slope of the Euro swap curve seems to have in the pre-crisis period (i) a negative impact on the spreads of straight and covered bonds, and (ii) no impact on the spreads of securitization bonds. Further, in the crisis period, the results also suggest (i) no impact on the spreads of straight and securitization bonds, and (ii) a negative impact on the spreads of covered bonds. These results imply that a steeper Euro swap curve is associated with lower spreads of covered bonds.

Regarding the characteristics of the banks, the results suggest the following. For straight bonds, in the pre-crisis period, the size of the bank (proxied by the natural logarithm of total assets) and the cost-to-income ratio are the only bank characteristics that impact (positively) spreads. The result regarding the size of the bank is contrary to expectations, since it implies that larger banks pay higher spreads. In contrast, in the crisis period, the size of the bank, the loan ratio and the liquid assets to deposits & ST funding ratio have a negative impact on spreads, while the loans to deposits ratio & ST funding ratio and the cost-to-income ratio have a positive impact on spreads. The result regarding the loan ratio is contrary to expectations.

For covered bonds, in the pre-crisis period, no bank characteristic impacts spreads. In contrast, in the crisis period, the size of the bank and the liquid assets to deposits & ST

funding ratio have a negative impact on spreads while the cost-to-income ratio has a positive impact on spreads. All results are in line with expectations.

Finally, for securitization bonds, in the pre-crisis period, the size of the bank and the loans to deposits ratio & ST funding ratio have a positive impact on spreads, while the loan ratio and the liquid assets to deposits & ST funding ratio have a negative impact on spreads. The results regarding the size of the bank and the loan ratio are contrary to expectations. The reason for this latter result may lie in fact that banks with a higher proportion of net loans to total assets have a larger loan's portfolio and thus more options to include loans with lower credit risk in the asset pool to be collateralized. In the crisis period, the size of the bank, the return on assets and the cost-to-income ratio have a positive impact on spreads. The results regarding the size of the bank and the return on assets are contrary to expectations.

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